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Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004

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For More Information

Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2004 (EPA420-R-O4-001) is available electronically on the Office of Transportation and Air Quality's (OTAQ) Web site at:

http://www.epa.gov/otaq/fetrends.htm

Printed copies are available from the OTAQ library at:

U.S. Environmental Protection Agency
Office of Transportation and Air Quality Library
2000 Traverwood Drive
Ann Arbor, MI 48105
(734) 214-4311

A copy of the *Fuel Economy Guide* giving city and highway fuel economy data for individual models is available at

http://www.fueleconomy.gov

or by calling the U.S. Department of Energy's National Alternative Fuels Hotline at (800) 423-1363.

EPA's *Green Vehicle Guide* provides information about the air pollution emissions and fuel economy performance of individual models is available on EPA's web site at

http://www.epa.gov/greenvehicles/

For information about the Department of Transportation (DOT) Corporate Average Fuel Economy (CAFE) program, including a program overview, related rulemaking activities, research, and summaries of individual manufacturers' fuel economy performance since 1978, see:

http://www.nhtsa.dot.gov/cars/rules/cafe/index.htm

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I. Executive Summary

Introduction

This report summarizes key fuel economy and technology usage trends related to model year 1975 through 2004 light-duty vehicles sold in the United States. Light-duty vehicles are those vehicles that EPA classifies as cars or light-duty trucks (sport utility vehicles, vans, and pickup trucks with less than 8,500 pounds gross vehicle weight ratings).

Model year 2004 light-duty vehicles are estimated to average 20.8 miles per gallon (MPG). The MY2004 average is within the 20.6 to 20.9 mpg range that has occurred for the past eight years, but six percent below the 1987-88 peak of 22.1 MPG

Since 1975, the fuel economy of the combined car and light truck fleet has moved through four phases:

1. a rapid increase from 1975 continuing to the mid-1980s,

2. a slow increase extending into the late 1980s,

3. a gradual decline from then until the late 1990s, and

4. a period of relatively constant fuel economy since then.

The fuel economy values in this report are based on 'real world' estimates provided by the Federal government to consumers and are about 15 percent lower than the fuel economy values used by manufacturers and the Department of Transportation (DOT) for compliance with the Corporate Average Fuel Economy (CAFE) program.

For model year 2004, light trucks are projected to account for 48 percent of all light-duty vehicles. After over two decades of steady growth, the market share for light trucks has been about half of the overall light-duty vehicle market since 2002. Most of this growth in the light truck market has been led by the increase in the popularity of sport utility vehicles(SUVs), which now account for more than one fourth of all new light-duty vehicles.

Model year 2004 light-duty vehicles are estimated to be heavier and more powerful than in 2003. This continues a twenty-plus year trend of increasing vehicle weight and power due to ongoing technological innovations commercialized by vehicle manufacturers in response to consumer demands.

Importance of Fuel Economy

Fuel economy continues to be a major area of public and policy interest for several reasons, including:

1. Fuel economy is directly related to energy security because light-duty vehicles account for approximately 40 percent of all U.S. oil consumption and much of this oil is imported.

2. Fuel economy is directly related to the cost of fueling a vehicle and is of great interest when oil and gasoline prices rise.

3. Fuel economy is directly related to emissions of greenhouse gases such as carbon dioxide. Light-duty vehicles contribute about 20 percent of all U.S. carbon dioxide emissions.

Characteristics of Light-Duty Vehicles for Three Model Years

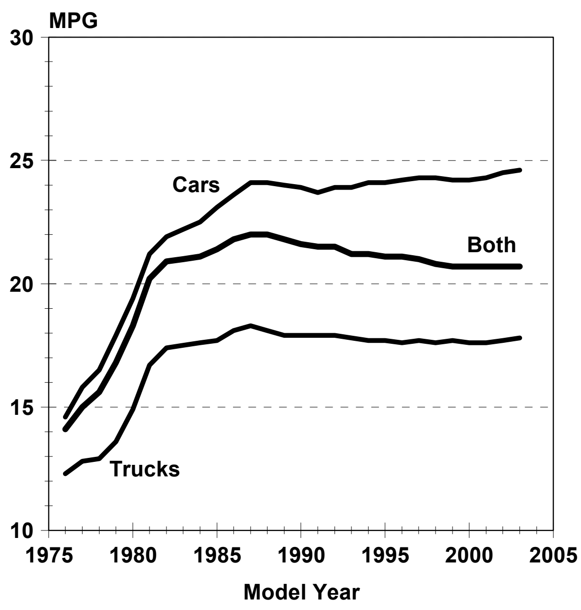
	1975	**1987**	**2004**
Adjusted Fuel Economy	13.1	22.1	20.8
Weight (lbs)	4060	3220	4066
Horsepower	137	118	208
0 to 60 Time (sec)	14.1	13.1	10.0
Percent Truck	19%	28%	48%

Highlight #1: Fuel Economy Has Been Relatively Constant For Several Years.

After a decade of decline from 1988 to 1997, fuel economy has been constant for several years. The average fuel economy for all model year 2004 light-duty vehicles is estimated to be 20.8 MPG - 6 percent lower than the peak value of 22.1 MPG achieved in 1987-88. Average model year 2004 fuel economy is 24.6 MPG for cars and 17.9 MPG for light trucks.

Since 1975, the fuel economy of the combined car and light truck fleet has moved through several phases: (1) a rapid increase from 1975 to the mid-1980s, (2) a slow increase extending into the late 1980s, (3) a decline from the peak in the late 1980s, and (4) since then a period of relatively constant overall fleet fuel economy. Viewing new cars and trucks separately, the three-year moving average fuel economy for cars has increased 1.0 MPG since 1991, but that for trucks has been relatively constant.

Adjusted Fuel Economy by Model Year
(Three-Year Moving Average)



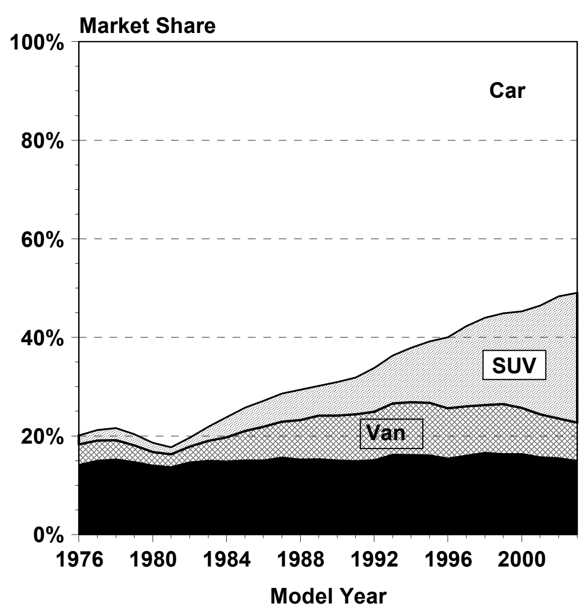
Highlight #2: Trucks Represent About Half of New Vehicle Sales.

Sales of light trucks, which include sport utility vehicles (SUVs), vans, and pickup trucks are now projected to make up 48 percent of the U.S. light-duty vehicle market -- more than twice their market share in 1984.

Growth in the light truck market has been led recently by the increase in the market share of SUVs. The SUV market share increased by more than a factor of ten, from less than two percent of the overall new light-duty vehicle market in 1975, to over 25 percent of the market now. Over the same period, the market share for vans increased by about three percent, while that for pickups remained relatively constant. Between 1975 and 2004, market share for new passenger cars and station wagons decreased from 81 to 52 percent. For model year 2004, cars are estimated to average 24.6 MPG, vans 20.0 MPG, SUVs 17.9 MPG, and pickups 17.0 MPG. The increased market share of light trucks, which in recent years have averaged more than six MPG less than cars, accounted for much of the decline in fuel economy of the overall new light-duty vehicle fleet from 1988 to 1997.

Sales Fraction by Vehicle Type

(Three-Year Moving Average)



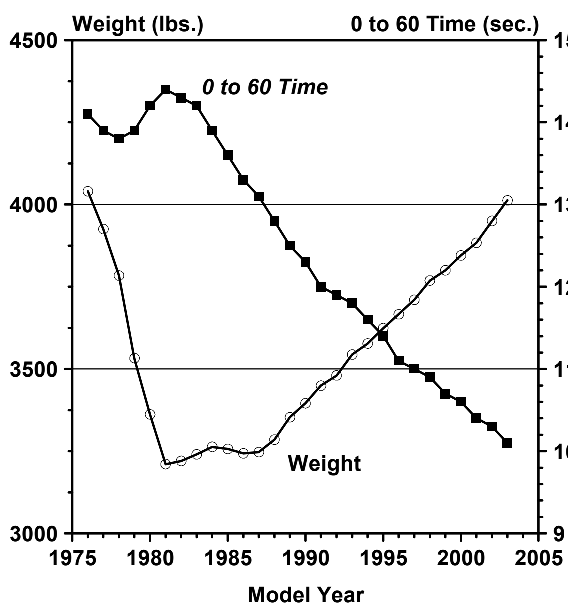
Highlight #3: As a Result of Technological Innovation, Vehicle Weight Has Increased and Performance Has Improved While Fuel Economy Has Remained Constant.

Manufacturers continue to apply technological innovations to the new light-duty vehicle fleet to increase light-duty vehicle weight and acceleration performance in response to consumer demands. EPA estimates that had the new 2004 light-duty vehicle fleet had the same distribution of performance and the same distribution of weight as in 1987, it could have achieved about 20 percent higher fuel economy.

Technologies—such as engines with more valves and more sophisticated fuel injection systems, and transmissions with lockup torque convertors and extra gears—continue to penetrate the new light-duty vehicle fleet. The trend has clearly been to apply these new technologies to accommodate increases in average new vehicle weight, power, and performance while maintaining a constant level of fuel economy. This is reflected by heavier average vehicle weight, rising average horsepower, and faster average 0 to 60 mile-per-hour acceleration time.

Weight and Performance

(Three Year Moving Average)



Important Notes With Respect to the Data Used in This Report

Unless otherwise indicated, the fuel economy values in this report are based on laboratory data and have been adjusted downward by about 15 percent, so that this data is equivalent to the real world estimates provided to consumers on new vehicle labels, in the EPA/DOE *Fuel Economy Guide,* and in EPA's *Green Vehicle Guide*. These adjusted fuel economy values are significantly lower than those used for compliance with CAFE standards as, in addition to the 15 percent downward adjustment for real world driving, they also exclude credits for alternative fuel capability and test procedure changes that are included in the CAFE data reported by the DOT.

The data presented in this report were tabulated on a model year basis, but several of the figures in this report use three-year moving averages which effectively smooth the trends, and these three-year moving averages are tabulated at their midpoint. For example, the midpoint for model years 2002, 2003, and 2004 is model year 2003. All average fuel economy values were calculated using harmonic, rather than arithmetic averaging.

The source database used to generate the tables and graphs in this report for all years, other than MY2003, was frozen in October 2003. When comparing data in this report with those in previous reports in this series, please note that revisions are made in the data for some recent model years for which more complete and accurate sales and fuel economy have become available.

Through model year 2002, the fuel economy, vehicle characteristics, and sales data used for this report were obtained from the most complete databases used for CAFE standards and "gas guzzler" compliance purposes.

Where available, the model year 2003 data in this report is based on CAFE compliance data submitted to EPA by March 31, 2004. For those MY2003 cases for which compliance data was yet not available, EPA used data that included confidential sales projections submitted to the Agency by the automotive manufacturers, but updated the sales data to take into account information reported in trade publications.

For model year 2004, EPA has exclusively used confidential projected sales data that the auto companies are required to submit to the Agency.

Over the last five years, the final fuel economy values have varied from 0.1 mpg lower to 0.3 mpg higher compared to the original estimates based exclusively on projected sales.

II. General Car and Truck Trends

The figures and tables in this report provide fuel economy data using two different approaches: the "laboratory" based or "unadjusted" values which have been used in many previous reports in this series and "adjusted" MPG values which are based on the adjustments made to the laboratory fuel economy values for the fuel economy information programs: the *Fuel Economy Guide*, new vehicle fuel economy labels, and the *Green Vehicle Guide*. The adjusted city MPG value is 0.90 times the laboratory city MPG value, and the adjusted highway MPG value is 0.78 times the laboratory MPG value. As described in the appendixes, these city and highway values are combined to form a composite 55/45 combined city/highway MPG. For a typical vehicle, the adjusted 55/45 MPG is about 15 percent less than the laboratory 55/45 MPG. Presenting both types of MPG values facilitates the use of this report by those who study either type of fuel economy metric.

In this report, "ton-MPG" is defined as a vehicle's adjusted MPG multiplied by its inertia weight in tons. This metric provides an indication of a vehicle's ability to move weight (i.e., its own plus a nominal payload). Ton-MPG is a measure of powertrain/drive-line efficiency. Just as an increase in vehicle MPG at constant weight can be considered an improvement in a vehicle's efficiency, an increase in a vehicle's weight-carrying capacity at constant MPG can also be considered an improvement. Appendix A contains a further description of the database and calculation methods used in this report.

The fuel economy databases that EPA uses for this report and other purposes are based on the consumer information and regulatory databases maintained by the Agency. For a given model year, these databases change with calendar time as the initial MPG values and sales projections available in the Fall of the year evolve toward final and more complete MPG data and actual production data. This calendar time-based process can take more than one year to complete and during this time, the database is changing. Therefore, the results for model years 2003 and 2004 that are obtained from using the database are estimates that depend on when the analysis is done.

Figure 1 and Table 1 depict time trends in car, light truck, and car-plus-light truck fuel economy. Also shown on Figure 1 is the fraction of the combined fleet that are light trucks and trend lines representing three-year moving averages of the fuel economy and truck sales fraction data.

Use of the three-year moving averages, which effectively smooth the trends, results in an improvement in discerning real trends from what might be relatively small year-to-year variations in the data. As shown in Table A-2 (see Appendix A), the three-year moving averages used in this report are tabulated and plotted at their midpoint. For example, the midpoint for model years 2002, 2003, and 2004 is model year 2003.

Since 1975, the fuel economy of the combined car and light truck fleet has moved through several phases:

1. a rapid increase from 1975 continuing into the mid-1980s,

2. a slow increase extending into the late 1980s,

3. a gradual decline from then until the late 1990s, and

4. a period of relatively constant fuel economy since then.

This fourth phase is characterized by three-year moving average MPG levels within 0.1 MPG of 24.3 MPG for laboratory fuel economy for six years. This 24.3 MPG value is 1.5 MPG (5.8%) lower than the highest year's (1987) three-year moving average value and 7.8 MPG (47%) higher than the earliest three-year moving average value, that for 1976.

Trends in the three-year moving average for car fuel economy have been like those for the overall fleet except car fuel economy has tended upward slightly for the last few years and is now higher than the previous peak for cars shown in the late 1990s.

Light truck fuel economy has been within 0.1 MPG of 20.7 for the last 10 years, based on three-year moving averages. This flat light truck fuel economy trend, accompanied by the increasing truck share of the market, has offset the recent upward trend in car fuel economy and has resulted in the recent flat trend in overall fleet fuel economy discussed above.

Figure 1 shows that the estimated light truck share of the market is about 48 percent and, based on the three-year moving average trend, has not yet leveled off. Table 2 shows some of the characteristics of each year's fleet. At 4066 lb, the average weight of the model year 2004 fleet is 45 lb heavier than last year's, 865 lb heavier than it was at the minimum in 1981-82, and the second heaviest since 1975. The model year 2004 fleet is also the most powerful and estimated to be the fastest since 1975.

Laboratory Fuel Economy and Percent Truck by Model Year

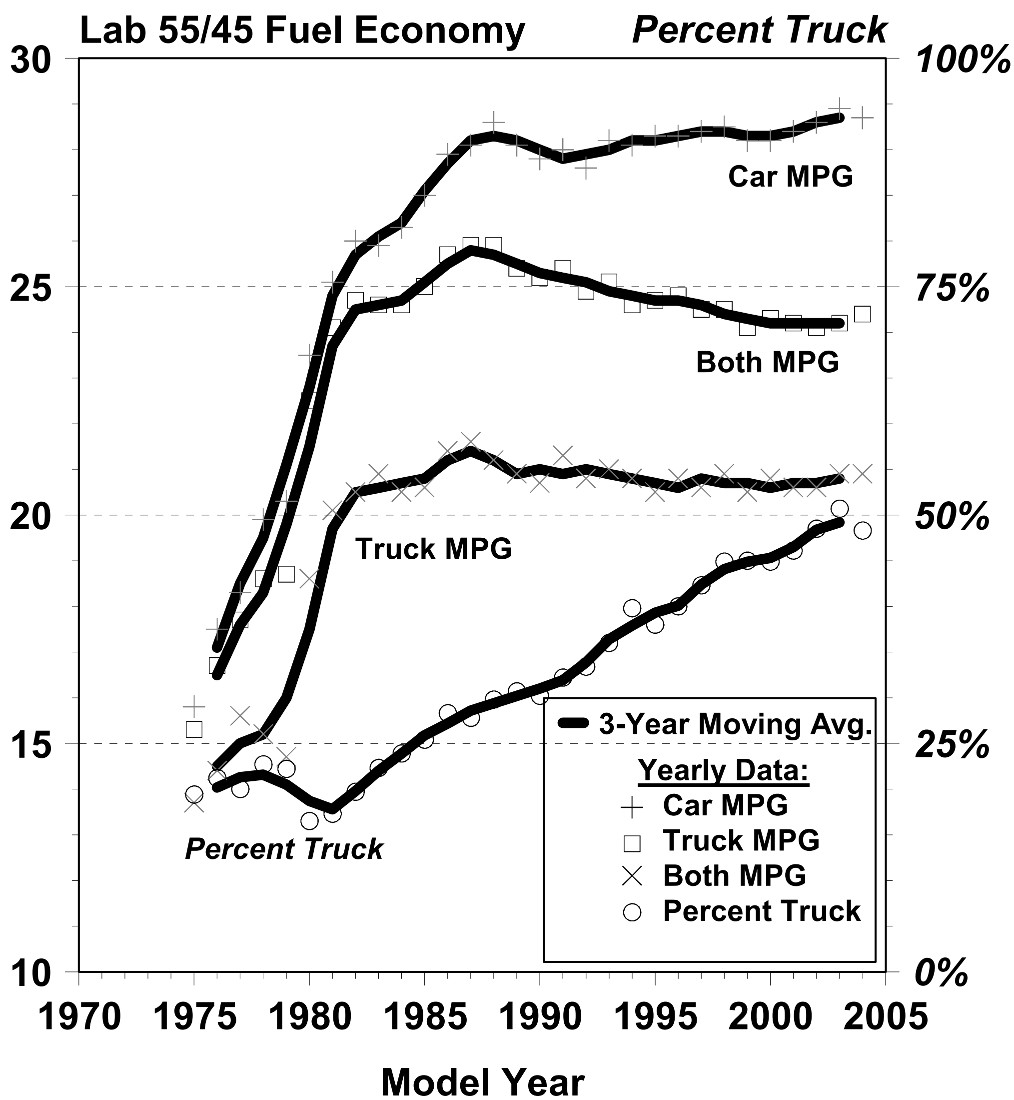


Figure 1

Table 1

Fuel Economy Characteristics of 1975 to 2004 Light-Duty Vehicles

Cars

MODEL YEAR	SALES (000)	FRAC	<---- FUEL ECONOMY LAB 55/45	ADJ CITY	ADJ HWY	----> ADJ 55/45	TON -MPG	CU-FT -MPG	CU-FT-TON-MPG
1975	8237	0.806	15.8	12.3	15.2	13.5	27.6		
1976	9722	0.788	17.5	13.7	16.6	14.9	30.2		
1977	11300	0.800	18.3	14.4	17.4	15.6	31.0	1780	3423
1978	11175	0.773	19.9	15.5	19.1	16.9	30.6	1908	3345
1979	10794	0.778	20.3	15.9	19.2	17.2	30.2	1922	3301
1980	9443	0.835	23.5	18.3	22.6	20.0	31.2	2136	3273
1981	8733	0.827	25.1	19.6	24.2	21.4	33.1	2338	3547
1982	7819	0.803	26.0	20.1	25.5	22.2	34.2	2419	3645
1983	8002	0.777	25.9	19.9	25.5	22.1	34.7	2476	3776
1984	10675	0.761	26.3	20.2	26.0	22.4	35.1	2482	3776
1985	10791	0.746	27.0	20.7	26.8	23.0	35.8	2551	3881
1986	11015	0.717	27.9	21.3	27.7	23.8	36.4	2608	3914
1987	10731	0.722	28.1	21.5	28.0	24.0	36.5	2604	3900
1988	10736	0.702	28.6	21.8	28.5	24.4	37.3	2662	4007
1989	10018	0.693	28.1	21.4	28.3	24.0	37.4	2630	4034
1990	8810	0.698	27.8	21.1	28.1	23.7	37.8	2574	4055
1991	8524	0.678	28.0	21.2	28.3	23.9	37.8	2597	4055
1992	8108	0.666	27.6	20.8	28.3	23.6	38.4	2598	4169
1993	8457	0.640	28.2	21.3	28.8	24.1	38.8	2655	4214
1994	8414	0.602	28.1	21.1	28.8	24.0	39.1	2638	4237
1995	9396	0.620	28.3	21.2	29.3	24.2	39.6	2676	4315
1996	7890	0.600	28.3	21.2	29.3	24.2	39.8	2671	4342
1997	8343	0.577	28.4	21.3	29.4	24.3	39.9	2674	4341
1998	7971	0.551	28.5	21.3	29.6	24.4	40.5	2684	4401
1999	8379	0.550	28.2	21.1	29.2	24.1	40.6	2656	4440
2000	9128	0.551	28.2	21.1	29.1	24.1	40.7	2542	4244
2001	8408	0.539	28.4	21.4	29.3	24.3	41.4	2700	4525
2002	8302	0.515	28.6	21.6	29.3	24.5	41.8	2723	4579
2003	7705	0.493	28.9	21.8	29.7	24.7	42.8	2741	4664
2004	8579	0.517	28.7	21.6	29.6	24.6	42.9	2766	4743

Table 1, Continued

Fuel Economy Characteristics of 1975 to 2004 Light-Duty Vehicles

Trucks

MODEL YEAR	SALES (000)	FRAC	<---- FUEL ECONOMY ----> LAB 55/45	ADJ CITY	ADJ HWY	ADJ 55/45	TON -MPG
1975	1987	0.194	13.7	10.9	12.7	11.6	24.2
1976	2612	0.212	14.4	11.5	13.2	12.2	26.0
1977	2823	0.200	15.6	12.6	14.1	13.3	28.0
1978	3273	0.227	15.2	12.4	13.7	12.9	27.5
1979	3088	0.222	14.7	12.1	13.1	12.5	27.3
1980	1863	0.165	18.6	14.8	17.1	15.8	30.9
1981	1821	0.173	20.1	16.0	18.6	17.1	33.0
1982	1914	0.197	20.5	16.3	19.0	17.4	33.7
1983	2300	0.223	20.9	16.5	19.6	17.8	34.0
1984	3345	0.239	20.5	16.1	19.3	17.4	33.5
1985	3669	0.254	20.6	16.2	19.4	17.5	33.7
1986	4350	0.283	21.4	16.9	20.2	18.3	34.4
1987	4134	0.278	21.6	16.9	20.7	18.4	34.5
1988	4559	0.298	21.2	16.5	20.4	18.1	34.9
1989	4435	0.307	20.9	16.3	20.1	17.8	35.2
1990	3805	0.302	20.7	16.1	20.2	17.7	35.6
1991	4049	0.322	21.3	16.4	20.7	18.1	36.0
1992	4064	0.334	20.8	16.1	20.4	17.8	36.2
1993	4754	0.360	21.0	16.1	20.7	17.9	36.6
1994	5572	0.398	20.8	16.0	20.4	17.7	36.7
1995	5749	0.380	20.5	15.8	20.2	17.5	36.9
1996	5254	0.400	20.8	16.0	20.7	17.8	37.8
1997	6124	0.423	20.6	15.8	20.4	17.6	38.3
1998	6485	0.449	20.9	16.0	20.8	17.8	38.3
1999	6854	0.450	20.5	15.7	20.3	17.5	38.6
2000	7447	0.449	20.8	16.0	20.5	17.7	38.9
2001	7189	0.461	20.6	15.9	20.2	17.6	39.3
2002	7804	0.485	20.6	15.8	20.3	17.6	40.0
2003	7917	0.507	20.9	16.0	20.7	17.8	41.0
2004	8023	0.483	20.9	16.0	20.8	17.9	42.1

Table 1, Continued

Fuel Economy Characteristics of 1975 to 2004

Cars and Trucks

MODEL YEAR	SALES (000)	FRAC	<---- FUEL ECONOMY ----> LAB 55/45	ADJ CITY	ADJ HWY	ADJ 55/45 ---->	TON -MPG
1975	10224	1.000	15.3	12.0	14.6	13.1	26.9
1976	12334	1.000	16.7	13.2	15.7	14.2	29.3
1977	14123	1.000	17.7	14.0	16.6	15.1	30.4
1978	14448	1.000	18.6	14.7	17.5	15.8	29.9
1979	13882	1.000	18.7	14.9	17.4	15.9	29.5
1980	11306	1.000	22.5	17.6	21.5	19.2	31.2
1981	10554	1.000	24.1	18.8	23.0	20.5	33.1
1982	9732	1.000	24.7	19.2	23.9	21.1	34.1
1983	10302	1.000	24.6	19.0	23.9	21.0	34.5
1984	14020	1.000	24.6	19.1	24.0	21.0	34.7
1985	14460	1.000	25.0	19.3	24.4	21.3	35.3
1986	15365	1.000	25.7	19.9	25.1	21.9	35.8
1987	14865	1.000	25.9	20.0	25.5	22.1	35.9
1988	15295	1.000	25.9	19.9	25.5	22.1	36.6
1989	14453	1.000	25.4	19.5	25.2	21.7	36.7
1990	12615	1.000	25.2	19.3	25.1	21.5	37.1
1991	12573	1.000	25.4	19.4	25.3	21.7	37.2
1992	12172	1.000	24.9	18.9	25.0	21.3	37.6
1993	13211	1.000	25.1	19.1	25.2	21.4	38.0
1994	13986	1.000	24.6	18.7	24.7	21.0	38.2
1995	15145	1.000	24.7	18.8	25.0	21.1	38.6
1996	13144	1.000	24.8	18.7	25.1	21.2	39.0
1997	14467	1.000	24.5	18.6	24.8	20.9	39.2
1998	14457	1.000	24.5	18.5	24.9	20.9	39.5
1999	15233	1.000	24.1	18.3	24.4	20.6	39.7
2000	16574	1.000	24.3	18.4	24.5	20.7	39.9
2001	15598	1.000	24.2	18.4	24.3	20.7	40.4
2002	16106	1.000	24.1	18.3	24.1	20.6	40.9
2003	15623	1.000	24.2	18.4	24.3	20.7	41.9
2004	16602	1.000	24.4	18.5	24.6	20.8	42.5

Table 2

Vehicles Size and Design Characteristics of 1975 to 2004 Cars

<------------ MEASURED CHARACTERISTICS -----------> <- PERCENT BY: ->

MODEL YEAR	SALES (000)	FRAC	ADJ 55/45 MPG	VOL CU-FT	INERTIA WGHT LB	ENG HP	HP/ WT	0-60 TIME	TOP SPD	VEHICLE SIZE SMALL	MID	LARGE
1975	8237	0.806	13.5		4057	136	0.0331	14.2	111	55.4	23.3	21.3
1976	9722	0.788	14.9		4058	134	0.0324	14.4	110	55.4	25.2	19.4
1977	11300	0.800	15.6	110	3943	133	0.0335	14.0	111	51.9	24.5	23.5
1978	11175	0.773	16.9	109	3587	124	0.0342	13.7	111	44.7	34.4	21.0
1979	10794	0.778	17.2	108	3484	119	0.0338	13.8	110	43.7	34.2	22.1
1980	9443	0.835	20.0	104	3101	100	0.0322	14.3	107	54.4	34.4	11.3
1981	8733	0.827	21.4	106	3075	99	0.0320	14.4	106	51.5	36.4	12.2
1982	7819	0.803	22.2	106	3054	99	0.0320	14.4	106	56.5	31.0	12.5
1983	8002	0.777	22.1	108	3111	104	0.0330	14.0	108	53.1	31.8	15.1
1984	10675	0.761	22.4	107	3098	106	0.0339	13.8	109	57.4	29.4	13.2
1985	10791	0.746	23.0	108	3092	111	0.0355	13.3	111	55.7	28.9	15.4
1986	11015	0.717	23.8	107	3040	111	0.0360	13.2	111	59.5	27.9	12.6
1987	10731	0.722	24.0	106	3030	112	0.0365	13.0	112	63.5	24.3	12.2
1988	10736	0.702	24.4	107	3046	116	0.0375	12.8	113	64.8	22.3	12.8
1989	10018	0.693	24.0	107	3099	121	0.0387	12.5	115	58.3	28.2	13.5
1990	8810	0.698	23.7	107	3175	129	0.0401	12.1	117	58.6	28.7	12.8
1991	8524	0.678	23.9	106	3153	132	0.0413	11.8	118	61.5	26.2	12.3
1992	8108	0.666	23.6	108	3239	141	0.0428	11.5	120	56.5	27.8	15.6
1993	8457	0.640	24.1	108	3207	138	0.0425	11.6	120	57.2	29.5	13.3
1994	8414	0.602	24.0	108	3249	143	0.0432	11.4	121	58.5	26.1	15.4
1995	9396	0.620	24.2	108	3262	152	0.0460	10.9	125	57.3	28.6	14.0
1996	7890	0.600	24.2	108	3281	154	0.0464	10.8	125	54.3	32.0	13.6
1997	8343	0.577	24.3	108	3273	156	0.0469	10.7	126	55.1	30.6	14.3
1998	7971	0.551	24.4	108	3306	159	0.0475	10.6	127	49.4	39.1	11.5
1999	8379	0.550	24.1	109	3364	164	0.0481	10.5	128	47.7	39.7	12.6
2000	9128	0.551	24.1	103	3369	168	0.0492	10.3	129	47.5	34.3	18.2
2001	8408	0.539	24.3	109	3379	168	0.0492	10.3	129	50.9	32.3	16.8
2002	8302	0.515	24.5	109	3391	173	0.0504	10.1	131	48.6	36.3	15.1
2003	7705	0.493	24.7	108	3431	178	0.0512	10.0	132	49.6	34.7	15.7
2004	8579	0.517	24.6	110	3462	183	0.0521	9.9	133	48.9	32.6	18.5

Table 2 (Continued)

Vehicles Size and Design Characteristics of 1975 to 2004 Trucks

			<-------- MEASURED CHARACTERISTICS -------->							<----------- PERCENT BY: ----------->					
			ADJ	INERTIA					VEHICLE SIZE			VEHICLE TYPE		
MODEL YEAR	SALES (000)	FRAC	55/45 MPG	WGHT LB	ENG HP	HP/ WT	0-60 TIME	TOP SPD	SMALL	MID	LARGE	VAN	SUV	PICKUP
1975	1987	0.194	11.6	4072	142	0.0349	13.6	114	10.9	24.2	64.9	23.0	9.4	67.6
1976	2612	0.212	12.2	4154	141	0.0340	13.8	113	9.0	20.3	70.7	19.2	9.3	71.4
1977	2823	0.200	13.3	4135	147	0.0356	13.3	115	11.1	20.3	68.5	18.2	10.0	71.8
1978	3273	0.227	12.9	4151	146	0.0351	13.4	114	10.9	22.7	66.3	19.1	11.6	69.3
1979	3088	0.222	12.5	4251	138	0.0325	14.3	111	15.2	19.5	65.3	15.6	13.0	71.5
1980	1863	0.165	15.8	3868	121	0.0313	14.5	108	28.4	17.6	54.0	13.0	9.9	77.1
1981	1821	0.173	17.1	3805	119	0.0311	14.6	108	23.2	19.1	57.7	13.5	7.5	79.1
1982	1914	0.197	17.4	3805	120	0.0317	14.5	109	21.1	31.0	47.9	16.2	8.5	75.3
1983	2300	0.223	17.8	3763	118	0.0313	14.5	108	16.6	45.9	37.6	16.6	12.6	70.8
1984	3345	0.239	17.4	3782	118	0.0310	14.7	108	19.5	46.4	34.1	20.2	18.7	61.1
1985	3669	0.254	17.5	3795	124	0.0326	14.1	110	19.2	48.5	32.3	23.3	20.0	56.6
1986	4350	0.283	18.3	3737	123	0.0330	14.0	110	23.5	48.5	28.0	24.0	17.8	58.2
1987	4134	0.278	18.4	3712	131	0.0351	13.3	113	19.9	59.6	20.6	26.9	21.1	51.9
1988	4559	0.298	18.1	3841	141	0.0366	12.9	115	15.0	57.2	27.8	24.8	21.2	53.9
1989	4435	0.307	17.8	3921	146	0.0372	12.8	116	13.9	58.9	27.2	28.8	20.9	50.3
1990	3805	0.302	17.7	4005	151	0.0377	12.6	117	13.4	57.1	29.6	33.2	18.6	48.2
1991	4049	0.322	18.1	3948	150	0.0379	12.6	117	11.4	67.2	21.4	25.5	27.0	47.4
1992	4064	0.334	17.8	4055	155	0.0382	12.5	118	10.4	64.0	25.6	30.0	24.7	45.3
1993	4754	0.360	17.9	4073	162	0.0398	12.1	120	8.8	65.3	25.9	30.3	27.6	42.1
1994	5572	0.398	17.7	4129	166	0.0402	12.0	121	9.8	62.5	27.7	25.0	28.5	46.5
1995	5749	0.380	17.5	4184	168	0.0401	12.0	121	8.6	63.5	27.9	28.9	31.6	39.5
1996	5254	0.400	17.8	4224	179	0.0423	11.5	124	6.5	67.1	26.4	26.8	36.0	37.2
1997	6124	0.423	17.6	4344	187	0.0429	11.4	126	10.1	52.5	37.3	20.7	40.0	39.3
1998	6485	0.449	17.8	4282	187	0.0435	11.2	126	8.9	58.7	32.4	23.0	39.8	37.2
1999	6854	0.450	17.5	4411	197	0.0445	11.0	128	7.7	55.8	36.5	21.4	41.4	37.2
2000	7447	0.449	17.7	4375	197	0.0448	11.0	128	6.7	55.7	37.5	22.7	42.2	35.1
2001	7189	0.461	17.6	4462	209	0.0466	10.6	131	6.6	47.4	46.0	17.2	46.3	36.5
2002	7804	0.485	17.6	4547	220	0.0482	10.4	134	6.6	43.6	49.9	15.9	53.6	30.5
2003	7917	0.507	17.8	4595	223	0.0485	10.3	134	6.4	49.0	44.6	16.3	53.7	30.0
2004	8023	0.483	17.9	4712	235	0.0498	10.1	137	5.2	45.6	49.3	14.5	54.0	31.5

Table 2 (Continued)

Vehicle Size and Design Characteristics of 1975 to 2004 Cars and Trucks

			<--------- MEASURED CHARACTERISTICS -------->						<- PERCENT BY: ->		
MODEL YEAR	SALES (000)	FRAC	ADJ 55/45 MPG	INERTIA WGHT LB	ENG HP	HP/ WT	0-60 TIME	TOP SPD	VEHICLE SIZE SMALL	MID	LARGE
1975	10224	1.000	13.1	4060	137	0.0335	14.1	112	46.8	23.5	29.8
1976	12334	1.000	14.2	4079	135	0.0328	14.3	111	45.6	24.2	30.3
1977	14123	1.000	15.1	3981	136	0.0339	13.8	112	43.8	23.7	32.5
1978	14448	1.000	15.8	3715	129	0.0344	13.6	112	37.0	31.7	31.2
1979	13882	1.000	15.9	3655	124	0.0335	13.9	110	37.3	30.9	31.7
1980	11306	1.000	19.2	3227	104	0.0320	14.3	107	50.1	31.6	18.3
1981	10554	1.000	20.5	3201	102	0.0318	14.4	107	46.6	33.4	20.0
1982	9732	1.000	21.1	3201	103	0.0320	14.4	107	49.6	31.0	19.5
1983	10302	1.000	21.0	3257	107	0.0327	14.1	108	44.9	34.9	20.1
1984	14020	1.000	21.0	3261	109	0.0332	14.0	109	48.4	33.4	18.2
1985	14460	1.000	21.3	3271	114	0.0347	13.5	110	46.5	33.9	19.7
1986	15365	1.000	21.9	3237	114	0.0351	13.4	111	49.3	33.7	17.0
1987	14865	1.000	22.1	3220	118	0.0361	13.1	112	51.4	34.1	14.5
1988	15295	1.000	22.1	3283	123	0.0372	12.8	114	50.0	32.7	17.3
1989	14453	1.000	21.7	3351	129	0.0382	12.5	115	44.7	37.6	17.7
1990	12615	1.000	21.5	3426	135	0.0394	12.2	117	44.9	37.2	17.8
1991	12573	1.000	21.7	3409	138	0.0402	12.1	118	45.3	39.4	15.2
1992	12172	1.000	21.3	3512	145	0.0413	11.8	120	41.1	39.9	19.0
1993	13211	1.000	21.4	3518	147	0.0416	11.8	120	39.8	42.4	17.8
1994	13986	1.000	21.0	3600	152	0.0420	11.7	121	39.1	40.6	20.3
1995	15145	1.000	21.1	3612	158	0.0438	11.3	123	38.8	41.9	19.3
1996	13144	1.000	21.2	3658	164	0.0447	11.1	125	35.2	46.0	18.7
1997	14467	1.000	20.9	3726	169	0.0452	11.0	126	36.1	39.9	24.1
1998	14457	1.000	20.9	3744	171	0.0457	10.9	126	31.2	47.9	20.8
1999	15233	1.000	20.6	3835	179	0.0465	10.7	128	29.7	46.9	23.4
2000	16574	1.000	20.7	3821	181	0.0472	10.6	129	29.2	43.9	26.9
2001	15598	1.000	20.7	3878	187	0.0480	10.5	130	30.4	39.3	30.3
2002	16106	1.000	20.6	3951	196	0.0493	10.2	132	28.2	39.8	31.9
2003	15623	1.000	20.7	4021	201	0.0498	10.2	133	27.7	42.0	30.3
2004	16602	1.000	20.8	4066	208	0.0510	10.0	135	27.8	38.9	33.3

Figure 1 shows graphically the increase in the percent of the fleet that is comprised of light trucks. Another dramatic trend over that time frame has been the substantial increase in performance of cars and light trucks as measured by their estimated 0-60 time. These trends are shown graphically in Figure 2 (for cars) and Figure 3 (for light trucks) which are plots of fuel economy versus performance, with model years as indicated. Both graphs show the same story: in responding to the regulatory requirements for MPG improvement, the industry increased MPG and kept performance roughly constant. After the regulatory MPG requirements stabilized, MPG improvements slowed and performance dramatically improved. This trend toward increased performance is as important as the truck market share trend in understanding trends in overall fleet MPG.

The distribution of MPG in any model year is of interest. In Figure 4, highlights of the distribution of car MPG are shown. Since 1975, the distribution has both narrowed and widened. Half of the cars have consistently been within a few MPG of each other, but the range of the highest to lowest has increased from about 3:1 in 1975 to about 6:1 today. In absolute terms, the fuel economy difference between the least efficient and most efficient car increased from about 20 MPG in 1975 to nearly 40 MPG a decade later in 1985, and became, since the introduction for sale of the Honda Insight gasoline-electric hybrid vehicle in model year 2000, more than 50 MPG.

The overall MPG distribution trend for trucks (see Figure 5) is similar to that for cars, but narrower with a peak in the efficiency of the most efficient truck in the early 1980s when small pickup trucks equipped with diesel engines were being sold. As a result, the fuel economy range between the most efficient and least efficient truck has narrowed from about 30 MPG in 1983 to about 14 MPG this year. Like cars, half of the trucks built each year have always been within a few MPG of each year's average fuel economy value.

Vehicles at the high end of the distribution are presented in Table 3. Cars and light trucks representing the top one percent of their respective distributions were selected for this table. For cars, hybrid, diesel, and conventional drivetrains are all represented as are continuously variable transmissions (CVTs), manual transmissions, and automatic transmissions. The cars all have 4-cylinder (or less) engines, front wheel drive, and weigh 3500 lb or less. Small and mid-size cars are included, but not large cars.

For light trucks, only conventional powertrains are represented. Both front and rear wheel drive are represented, as are automatic and manual transmissions; large vans, large pickups, and large SUVs are not represented.

Car 55/45 Laboratory MPG vs 0 to 60 Time

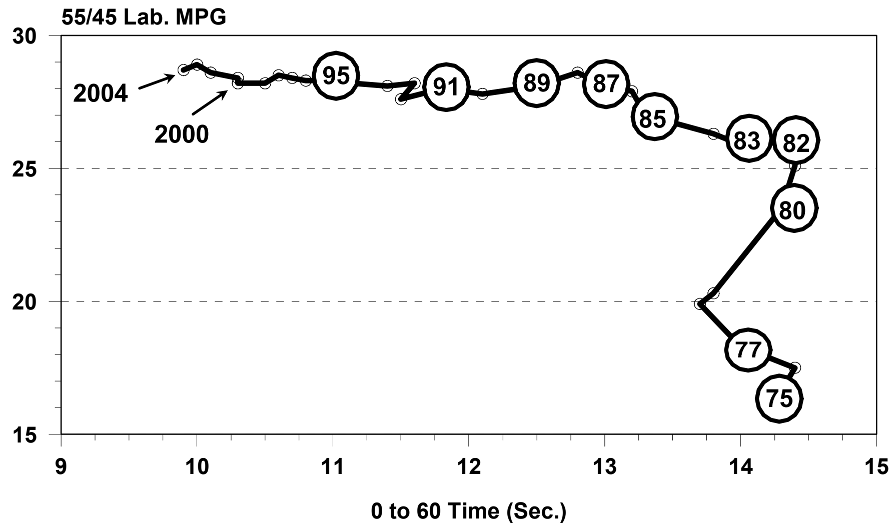


Figure 2

Light Truck 55/45 Laboratory MPG vs 0 to 60 Time

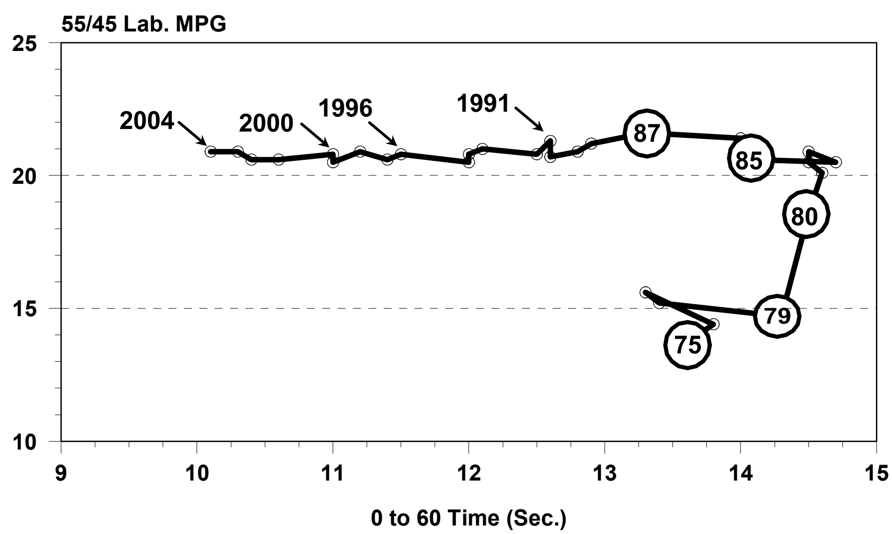


Figure 3

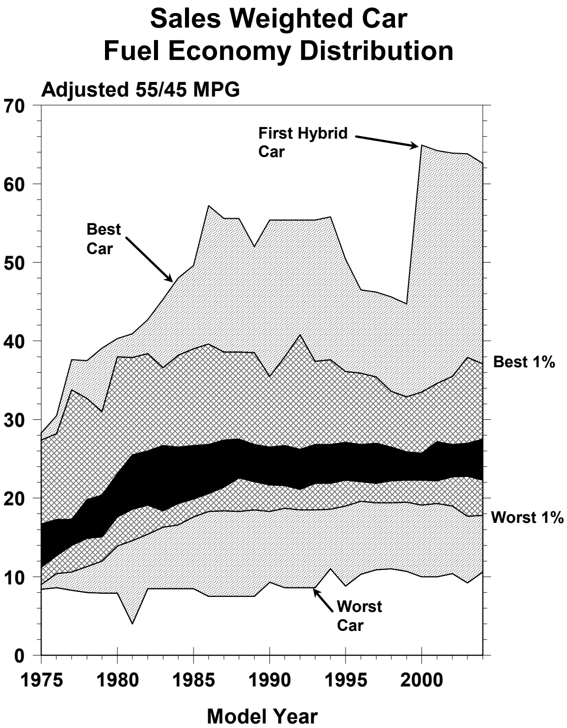


Figure 4

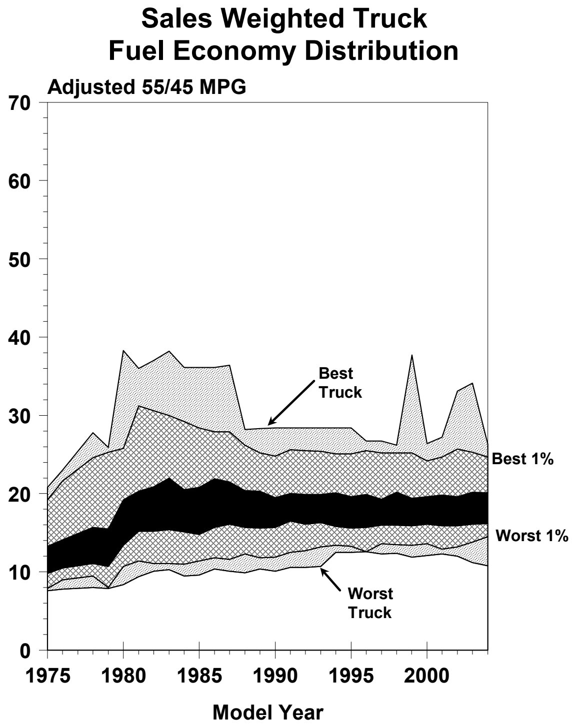


Figure 5

Table 3

Characteristics of Cars and Trucks with Relatively High Fuel Economy

MFR	Model Name	Inertia Weight	Drive	Engine CID	Engine HP	Trans	Vehicle Type/Size	Adjusted MPG	Ton-MPG
Cars									
Honda	Insight Hyb.	2000	Front	61	67	M5	Small Car	62.6	62.6
Honda	Insight Hyb.	2250	Front	61	65	CVT	Small Car	56.1	63.2
Toyota	Prius Hyb.	3000	Front	91	76	CVT	Midsize Car	55.3	83.0
Honda	Civic Hyb.	3000	Front	82	85	M5	Small Car	48.0	72.0
Honda	Civic Hyb.	3000	Front	82	85	CVT	Small Car	47.6	71.4
Honda	Civic Hyb.	3000	Front	82	85	CVT	Small Car	47.4	71.1
Honda	Civic Hyb.	3000	Front	82	85	M5	Small Car	47.3	71.0
VW	Diesels	3000	Front	116	100	M5	Small Car	41.2	61.8
VW	Jetta Dsl.	3500	Front	116	100	M5	Small Wagon	40.5	70.9
Honda	Civic	2750	Front	102	117	M5	Small Car	39.3	54.0
Toyota	Echo	2250	Front	91	108	M5	Small Car	38.6	43.5
VW	Diesels	3500	Front	116	100	L6	Small Car	38.3	66.9
Toyota	Echo	2500	Front	91	108	M5	Small Car	38.2	47.7
Honda	Civic	2750	Front	102	117	CVT	Small Car	37.0	50.8
VW	Diesels	3500	Front	116	100	L5	Small Wagon	37.1	64.9
Trucks									
Toyota	RAV4	3000	Front	161	144	L4	Small SUV	26.3	39.4
Toyota	RAV4	3000	Front	161	144	M5	Small SUV	26.3	39.4
GM	VUE	3500	Front	140	134	M5	Midsize SUV	25.8	45.1
Ford	Ranger	3500	Rear	140	140	M5	Midsize Pickup	25.7	45.0
Honda	CR-V	3500	Front	160	144	L4	Midsize SUV	25.0	43.8
Ford	Escape	3500	Front	130	122	M5	Midsize SUV	24.7	43.2

III. Technology Trends

Table 4 repeats some of the data from Tables 1 and 2 and adds powertrain information including front-wheel drive percent, transmission type, fuel metering, and percent of vehicles equipped with engines that have four valves per cylinder. Cars are predominantly powered by gasoline-fueled engines that use port fuel injection and have four valves per cylinder, and use lockup automatic transmissions driving the front wheels. Trucks have gasoline-fueled engines with port fuel injection and have two valves per cylinder, and use lockup automatic transmissions that drive the rear or all four wheels.

Table 5 compares technology usage for MY2004 by vehicle type and size. As discussed in Appendix A, wheelbase is used in this report to distinguish whether a truck is small, mid-size, or large, and four EPA Car Classes (Two-Seater, Minicompact, Compact, and Subcompact) have been combined to form the small car class. For this table, the car classes are separated into cars and station wagons, so that the table stratifies light-duty vehicles into a total of 15 vehicle types and sizes. Note that this table does not contain any data for small vans, because none have been produced since 1996.

In some of the tables and figures in this report, only four vehicle types are used. In these cases, wagons have been merged with cars. This is because the wagon sales fraction for some instances is so small that the information is more conveniently represented by combining the two vehicle types. When they have been combined, the differences between them are not important

Front-wheel drive (FWD) is used heavily in all of the car classes, in small wagons, and midsize vans. By comparison, none of this year’s pickups will have front-wheel drive, and little use of it is found in large vans or SUVs. Conversely, four-wheel drive (4WD) is used heavily in SUVs and pickups. Many of the midsize and large wagons also have 4WD, but very little use of it is made in vans and cars.

Manual transmissions are used more in small and mid-size vehicles in 2004 than in larger vehicles. Similarly, usage of engines with four valves per cylinder is prevalent on small vehicles and also midsize cars, wagons, and SUVs.

Detailed tabulations of different technology types, including technology usage percentages for other model years, can be found in the Appendixes.

Table 4

Powertrain Characteristics of 1975 to 2004 Vehicles

	<--- Measured Characteristics --->						<--- Percent by: --->									
MODEL YEAR	SALES (000)	FRAC	ADJ 55/45 MPG	ENGINE CID	ENGINE HP	HP/ CID	DRIVETRAIN FRONT	DRIVETRAIN 4WD	TRANSMISSION MANUAL	TRANSMISSION LOCK	FUEL METERING FI	FUEL METERING PORT	FUEL METERING TBI	CARB	DSL	FOUR VALVE
Cars																
1975	8237	0.806	13.5	288	136	0.515	6.5	0.0	19.9	0.0	5.1	5.1	0.0	94.6	0.2	0.0
1976	9722	0.788	14.9	287	134	0.502	5.8	0.0	17.1	0.0	3.2	3.2	0.0	96.6	0.3	0.0
1977	11300	0.800	15.6	279	133	0.516	6.8	0.0	16.8	0.0	4.2	4.2	0.0	95.3	0.5	0.0
1978	11175	0.773	16.9	251	124	0.538	9.6	0.0	20.2	6.7	5.1	5.1	0.0	94.0	0.9	0.0
1979	10794	0.778	17.2	238	119	0.545	11.9	0.3	22.3	8.0	4.7	4.7	0.0	93.2	2.1	0.0
1980	9443	0.835	20.0	188	100	0.583	29.7	0.9	31.9	16.5	6.9	6.2	0.7	88.7	4.4	0.0
1981	8733	0.827	21.4	182	99	0.594	37.0	0.7	30.4	33.3	8.8	6.1	2.6	85.3	5.9	0.0
1982	7819	0.803	22.2	175	99	0.609	45.6	0.8	29.7	51.4	17.0	7.2	9.8	78.4	4.7	0.0
1983	8002	0.777	22.1	182	104	0.615	47.3	3.1	26.5	56.7	28.3	9.5	18.9	69.6	2.1	0.0
1984	10675	0.761	22.4	179	106	0.637	53.7	1.0	24.1	58.3	39.4	15.0	24.4	58.9	1.7	0.0
1985	10791	0.746	23.0	177	111	0.671	61.6	2.1	22.8	58.7	53.5	21.4	32.0	45.6	0.9	0.0
1986	11015	0.717	23.8	167	111	0.701	71.1	1.1	24.8	58.0	65.1	36.7	28.4	34.5	0.3	1.6
1987	10731	0.722	24.0	162	112	0.732	77.0	1.1	24.9	59.5	73.0	42.5	30.5	26.8	0.3	5.6
1988	10736	0.702	24.4	160	116	0.759	81.7	0.8	24.3	66.1	83.7	53.7	30.0	16.3	0.0	10.4
1989	10018	0.693	24.0	163	121	0.783	82.5	1.0	21.0	69.3	90.2	62.4	27.8	9.7	0.0	12.8
1990	8810	0.698	23.7	163	129	0.829	84.6	1.0	19.6	72.9	98.6	77.5	21.1	1.4	0.0	25.7
1991	8524	0.678	23.9	163	132	0.851	83.2	1.4	20.5	73.5	99.8	78.0	21.8	0.0	0.1	28.2
1992	8108	0.666	23.6	170	141	0.868	80.8	1.1	17.4	76.4	99.9	89.5	10.4	0.0	0.1	29.7
1993	8457	0.640	24.1	166	138	0.865	85.1	1.2	17.8	76.9	100.0	91.6	8.4	0.0	0.0	32.8
1994	8414	0.602	24.0	168	143	0.884	84.4	0.4	16.7	79.3	100.0	94.9	5.1	0.0	0.0	38.9
1995	9396	0.620	24.2	167	152	0.945	82.0	1.2	16.3	81.9	99.9	98.8	1.2	0.0	0.1	52.1
1996	7890	0.600	24.2	165	154	0.958	86.5	1.5	14.9	83.6	99.9	98.8	1.1	0.0	0.1	56.2
1997	8343	0.577	24.3	164	156	0.974	86.6	1.7	13.5	85.8	99.9	99.1	0.8	0.0	0.1	57.4
1998	7971	0.551	24.4	164	159	0.993	87.0	2.3	12.3	87.4	99.8	99.7	0.1	0.0	0.2	60.5
1999	8379	0.550	24.1	166	164	1.008	87.2	2.2	10.9	88.4	99.8	99.7	0.1	0.0	0.2	59.4
2000	9128	0.551	24.1	165	168	1.032	84.9	2.1	11.2	87.7	99.8	99.7	0.1	0.0	0.2	63.2
2001	8408	0.539	24.3	165	168	1.042	84.1	3.2	11.4	87.5	99.7	99.7	0.0	0.0	0.3	61.8
2002	8302	0.515	24.5	166	173	1.066	84.9	3.8	11.5	87.8	99.6	99.6	0.0	0.0	0.4	65.0
2003	7705	0.493	24.7	171	178	1.084	81.9	3.2	10.8	88.3	99.6	99.6	0.0	0.0	0.4	67.9
2004	8579	0.517	24.6	170	183	1.096	80.2	5.0	13.0	84.6	99.8	99.8	0.0	0.0	0.2	69.1

Table 4, Continued

Powertrain Characteristics of 1975 to 2004 Vehicles

<- Measured Characteristics -> <---------------------------- Percent by: ------------------------->

MODEL YEAR	SALES (000)	FRAC	ADJ 55/45	ENGINE CID	ENGINE HP	HP/ CID	DRIVETRAIN FRONT	DRIVETRAIN 4WD	TRANSMISSION MANUAL	TRANSMISSION LOCK	FUEL METERING FI	FUEL METERING PORT	FUEL METERING TBI	CARB	DSL	FOUR VALVE
Trucks																
1975	1987	0.194	11.6	311	142	0.476	0.0	17.1	37.0	0.0	0.1	0.0	0.0	99.9	0.0	0.0
1976	2612	0.212	12.2	319	141	0.458	0.0	22.9	34.8	0.0	0.1	0.0	0.0	99.9	0.0	0.0
1977	2823	0.200	13.3	318	147	0.482	0.0	23.6	32.0	0.0	0.1	0.0	0.0	99.9	0.0	0.0
1978	3273	0.227	12.9	314	146	0.481	0.0	29.0	32.4	0.0	0.1	0.0	0.0	99.1	0.8	0.0
1979	3088	0.222	12.5	298	138	0.486	0.0	18.0	35.2	2.1	0.3	0.0	0.0	97.9	1.8	0.0
1980	1863	0.165	15.8	248	121	0.528	1.4	25.0	53.0	24.6	1.7	0.0	0.0	94.9	3.5	0.0
1981	1821	0.173	17.1	247	119	0.508	1.9	20.1	51.6	31.1	1.1	0.0	0.0	93.3	5.6	0.0
1982	1914	0.197	17.4	243	120	0.524	1.7	20.0	45.7	33.2	0.7	0.0	0.0	90.0	9.3	0.0
1983	2300	0.223	17.8	231	118	0.543	1.4	25.8	45.9	36.1	0.6	0.0	0.0	94.7	4.7	0.0
1984	3345	0.239	17.4	224	118	0.557	4.9	31.0	42.1	35.1	2.6	0.0	0.0	95.1	2.3	0.0
1985	3669	0.254	17.5	224	124	0.586	7.1	30.6	37.1	42.2	12.3	0.0	0.2	86.7	1.1	0.0
1986	4350	0.283	18.3	211	123	0.621	5.9	30.3	42.7	42.0	40.5	21.8	18.7	58.7	0.7	0.0
1987	4134	0.278	18.4	210	131	0.654	7.4	31.5	39.9	44.8	66.9	33.3	33.6	32.9	0.3	0.0
1988	4559	0.298	18.1	227	141	0.650	9.0	33.3	35.5	53.1	87.7	43.3	44.4	12.1	0.2	0.0
1989	4435	0.307	17.8	234	146	0.653	9.9	32.0	32.7	56.8	93.5	45.9	47.6	6.3	0.2	0.0
1990	3805	0.302	17.7	237	151	0.668	15.5	31.3	28.1	67.4	96.0	55.2	40.8	3.9	0.2	0.0
1991	4049	0.322	18.1	228	150	0.681	9.7	35.3	31.0	67.4	98.2	55.0	43.2	1.6	0.1	0.0
1992	4064	0.334	17.8	234	155	0.685	13.6	31.4	27.3	71.5	98.4	65.9	32.5	1.5	0.1	0.0
1993	4754	0.360	17.9	235	162	0.710	15.1	29.5	23.3	75.7	99.0	73.4	25.7	1.0	0.0	0.2
1994	5572	0.398	17.7	240	166	0.716	13.3	37.4	23.3	75.2	99.6	76.8	22.8	0.4	0.0	2.5
1995	5749	0.380	17.5	244	168	0.715	17.7	40.7	20.5	78.6	100.0	79.8	20.2	0.0	0.0	8.1
1996	5254	0.400	17.8	243	179	0.757	20.1	37.1	15.6	83.5	99.9	99.9	0.0	0.0	0.1	10.4
1997	6124	0.423	17.6	248	187	0.775	13.9	43.2	14.6	85.0	100.0	100.0	0.0	0.0	0.0	11.3
1998	6485	0.449	17.8	242	187	0.795	18.7	42.0	13.4	86.0	100.0	100.0	0.0	0.0	0.0	15.2
1999	6854	0.450	17.5	249	197	0.814	17.3	44.6	9.1	90.5	100.0	100.0	0.0	0.0	0.0	16.2
2000	7447	0.449	17.7	242	197	0.832	19.4	42.4	8.0	91.7	100.0	100.0	0.0	0.0	0.0	20.4
2001	7189	0.461	17.6	243	209	0.882	18.5	43.8	6.3	93.4	100.0	100.0	0.0	0.0	0.0	27.1
2002	7804	0.485	17.6	244	220	0.918	18.5	47.5	5.0	94.7	100.0	100.0	0.0	0.0	0.0	35.0
2003	7917	0.507	17.8	245	223	0.929	18.9	47.1	4.2	94.3	100.0	100.0	0.0	0.0	0.0	36.4
2004	8023	0.483	17.9	251	235	0.955	18.5	49.6	4.1	94.6	100.0	100.0	0.0	0.0	0.0	44.3

Table 4, Continued

Powertrain Characteristics of 1975 to 2004 Vehicles

	<- Measured Characteristics ->						<- Percent by: ->									
MODEL	SALES		ADJ	ENGINE		HP/	DRIVETRAIN		TRANSMISSION		FUEL METERING					FOUR
YEAR	(000)	FRAC	55/45	CID	HP	CID	FRONT	4WD	MANUAL	LOCK	FI	PORT	TBI	CARB	DSL	VALVE
Both																
1975	10224	1.000	13.1	293	137	0.507	5.3	3.3	23.2	0.0	4.1	4.1	0.0	95.7	0.2	0.0
1976	12334	1.000	14.2	294	135	0.493	4.6	4.8	20.9	0.0	2.5	2.5	0.0	97.3	0.2	0.0
1977	14123	1.000	15.1	287	136	0.510	5.5	4.7	19.8	0.0	3.4	3.4	0.0	96.2	0.4	0.0
1978	14448	1.000	15.8	266	129	0.525	7.4	6.6	23.0	5.2	3.9	3.9	0.0	95.2	0.9	0.0
1979	13882	1.000	15.9	252	124	0.532	9.2	4.3	25.1	6.7	3.7	3.7	0.0	94.2	2.0	0.0
1980	11306	1.000	19.2	198	104	0.574	25.0	4.9	35.4	17.8	6.0	5.2	0.6	89.7	4.3	0.0
1981	10554	1.000	20.5	193	102	0.580	31.0	4.0	34.1	33.0	7.5	5.1	2.2	86.7	5.9	0.0
1982	9732	1.000	21.1	188	103	0.593	37.0	4.6	32.8	47.8	13.8	5.8	7.9	80.6	5.6	0.0
1983	10302	1.000	21.0	193	107	0.599	37.0	8.1	30.8	52.1	22.1	7.3	14.7	75.2	2.7	0.0
1984	14020	1.000	21.0	190	109	0.618	42.1	8.2	28.4	52.8	30.6	11.4	18.6	67.6	1.8	0.0
1985	14460	1.000	21.3	189	114	0.650	47.8	9.3	26.5	54.5	43.0	16.0	23.9	56.1	0.9	0.0
1986	15365	1.000	21.9	180	114	0.678	52.6	9.3	29.8	53.5	58.2	32.5	25.7	41.4	0.4	1.1
1987	14865	1.000	22.1	175	118	0.710	57.7	9.6	29.1	55.4	71.3	39.9	31.4	28.4	0.3	4.0
1988	15295	1.000	22.1	180	123	0.726	60.0	10.5	27.6	62.2	84.9	50.6	34.3	15.0	0.1	7.3
1989	14453	1.000	21.7	185	129	0.743	60.2	10.5	24.6	65.5	91.2	57.3	33.9	8.7	0.1	8.9
1990	12615	1.000	21.5	185	135	0.781	63.8	10.1	22.2	71.2	97.8	70.8	27.0	2.1	0.1	17.9
1991	12573	1.000	21.7	184	138	0.796	59.6	12.3	23.9	71.6	99.3	70.6	28.7	0.6	0.1	19.1
1992	12172	1.000	21.3	191	145	0.807	58.4	11.2	20.7	74.8	99.4	81.6	17.8	0.5	0.1	19.8
1993	13211	1.000	21.4	191	147	0.809	59.9	11.4	19.8	76.5	99.7	85.0	14.6	0.3	0.0	21.1
1994	13986	1.000	21.0	196	152	0.817	56.1	15.1	19.4	77.7	99.9	87.7	12.2	0.1	0.0	24.4
1995	15145	1.000	21.1	196	158	0.857	57.6	16.2	17.9	80.7	100.0	91.6	8.4	0.0	0.0	35.4
1996	13144	1.000	21.2	197	164	0.878	60.0	15.7	15.2	83.5	99.9	99.3	0.7	0.0	0.1	37.9
1997	14467	1.000	20.9	199	169	0.890	55.8	19.3	13.9	85.5	99.9	99.5	0.5	0.0	0.1	37.9
1998	14457	1.000	20.9	199	171	0.904	56.4	20.1	12.8	86.8	99.9	99.8	0.1	0.0	0.1	40.2
1999	15233	1.000	20.6	203	179	0.920	55.8	21.3	10.1	89.4	99.9	99.9	0.1	0.0	0.1	39.9
2000	16574	1.000	20.7	200	181	0.942	55.5	20.2	9.7	89.5	99.9	99.8	0.0	0.0	0.1	44.0
2001	15598	1.000	20.7	201	187	0.968	53.9	22.0	9.0	90.2	99.9	99.9	0.0	0.0	0.1	45.8
2002	16106	1.000	20.6	203	196	0.994	52.7	25.0	8.3	91.2	99.8	99.8	0.0	0.0	0.2	50.4
2003	15623	1.000	20.7	209	201	1.005	50.0	25.4	7.4	90.0	99.8	99.8	0.0	0.0	0.2	52.0
2004	16602	1.000	20.8	209	208	1.028	50.3	26.6	8.7	89.4	99.9	99.9	0.0	0.0	0.1	57.1

Table 5

MY2004 Technology Usage by Vehicle Type and Size
(Percent of Vehicle Type/Size Strata)

Vehicle Type	Size	Front Wheel Drive	Four Wheel Drive	Manual Trans.	Four valves per Cylinder
Car	Small	75	6	23	76
	Midsize	91	1	6	76
	Large	78	1	0	33
	All	81	3	13	68
Wagon	Small	84	15	22	93
	Midsize	47	51	9	75
	Large	50	50	0	100
	All	70	29	16	89
Van	Small	--	--	--	--
	Midsize	93	4	0	48
	Large	0	16	0	0
	All	85	5	0	44
SUV	Small	18	77	24	79
	Midsize	18	65	3	65
	Large	3	68	0	45
	All	12	67	3	57
Pickup	Small	0	51	27	100
	Midsize	0	32	21	23
	Large	0	41	4	15
	All	0	41	8	23
All	Cars and Wagons	80	5	13	69
All	Trucks	19	50	4	44
All	Vehicles	51	27	9	57

Figures 6 through 10 show trends in drive use for the five vehicle classes. Cars used to be all rear-wheel drive (RWD), now they are over 80 percent front-wheel drive with a small four-wheel drive fraction, and the trend is flat. Only a small percentage of wagons still have rear-wheel drive, but in recent years they have made substantial use of 4WD.

Drive usage for vans is similar to that for cars, although the trend since the introduction of FWD vans is sharper than it was for cars and appears to be continuing. SUVs are mostly 4WD; with the beginning of a trend toward FWD just showing up recently. Pickups remain the bastion of RWD with the increasing amount of 4WD the only other drive option. Except for a brief period in the early 1980s, front-wheel drive has not been used in pickups.

Front, Rear and Four Wheel Drive Usage

Cars

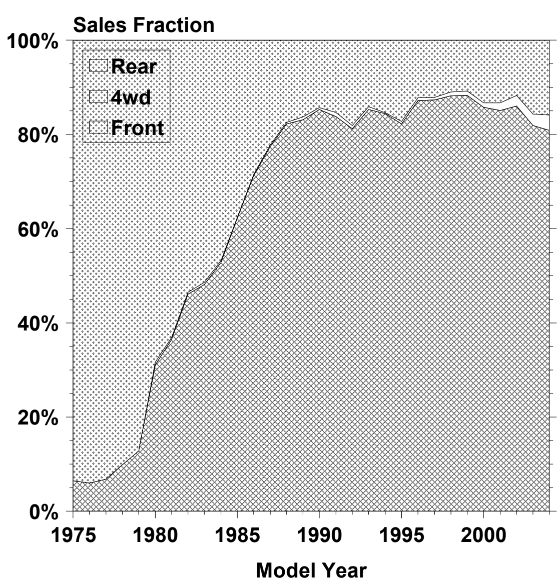


Figure 6

Front, Rear and Four Wheel Drive Usage

Wagons

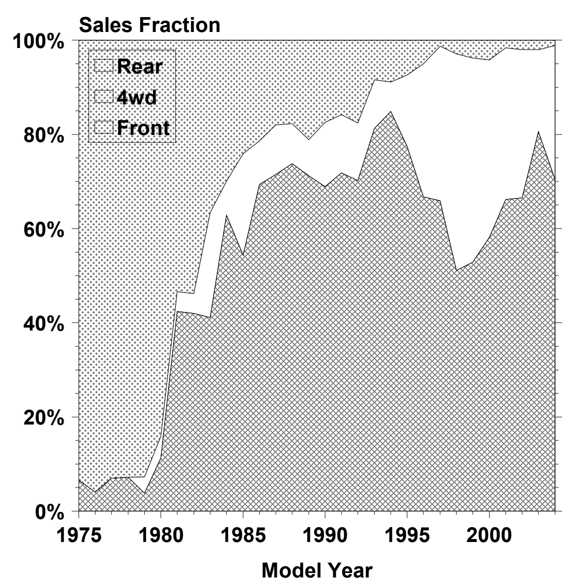


Figure 7

Front, Rear and Four Wheel Drive Usage
Vans

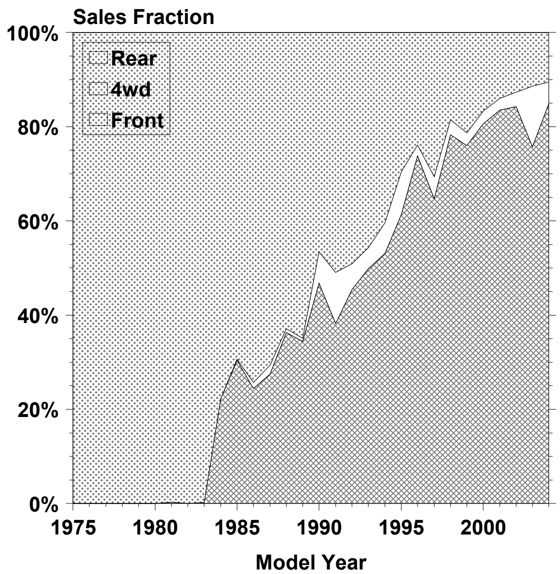


Figure 8

Front, Rear and Four Wheel Drive Usage
SUVs

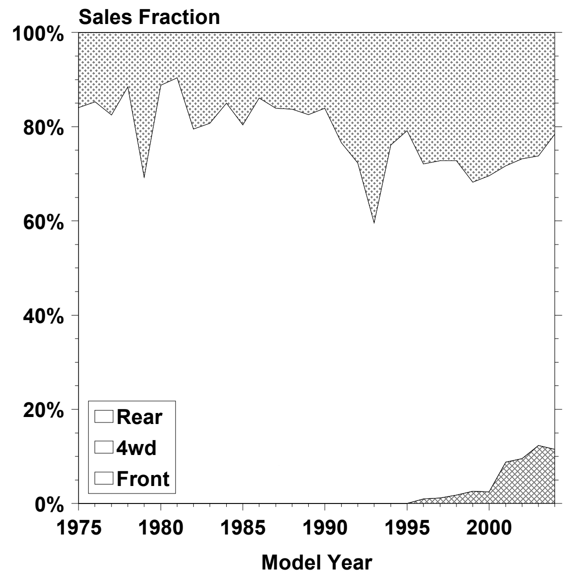


Figure 9

Front, Rear and Four Wheel Drive Usage
Pickups

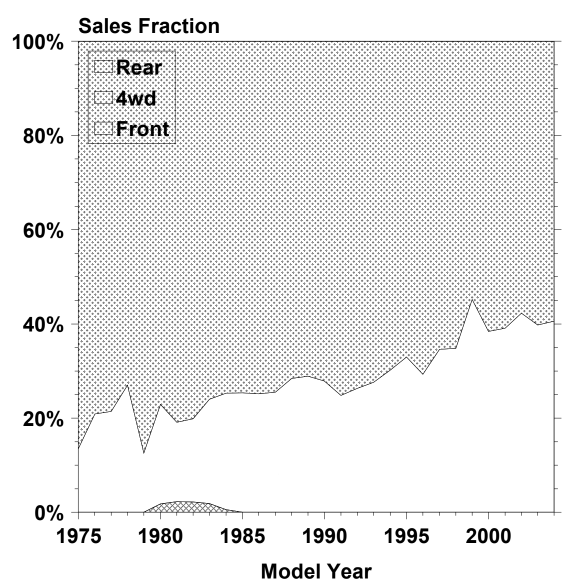


Figure 10

Three important changes in transmission design have occurred in recent years:

1) the addition of a gear for both automatic and manual transmissions,

2) for the automatics, conversion to lockup (L3, L4, or L5) torque converter transmissions, and

3) the use of continuously variable transmissions (CVTs).

Figures 11 to 14 indicate that the L4 transmission is currently the predominant transmission type for all vehicle classes. For purposes of this analysis, cars and wagons have been combined as "cars," because the trends for wagons are not significantly different from that for cars. Where manual transmissions are used, the 5-speed (M5) transmission now predominates.

A small fraction (too small to show on the figures) of vehicles are equipped with M6 and L6 transmissions in MY2004. More data stratified by transmission type can be found in Appendix J.

The increasing trend in Ton-MPG shown in Table 1 can be attributed to better vehicle design, including more efficient engines, better transmission design, and better matching of the engine and transmission. Powertrains are matched to the load better when the engine operates closer to its best efficiency point more of the time. For many conventional engines, this point is approximately 2000 RPM and 2/3 of the maximum torque at that speed. One way to make the engine operate more closely to its best efficiency point is to increase the number of gears in the transmission and, for automatic transmissions, employing a lockup torque converter.

Table 6 compares Ton-MPG by transmission and vehicle type between 1987, the peak year for passenger car fuel economy, and this year. For nearly every strata for which the equivalent vehicle type used the same transmission type in both years shown in the table, Ton-MPG will be higher this year than it was in 1987. For model year 2004, cars, pickups, and SUVs equipped with L5 transmissions will achieve about the same Ton-MPG as their MY2004 M5-equipped counterparts. Similarly, for all four vehicle types, MY2004 vehicles with L4 transmissions achieve better Ton-MPG this year than any of the corresponding vehicles did in 1987.

Transmission Sales Fraction

Cars

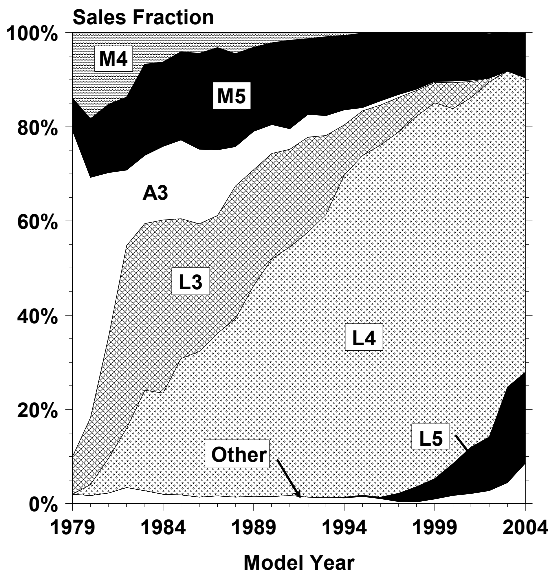


Figure 11

Transmission Sales Fraction

Vans

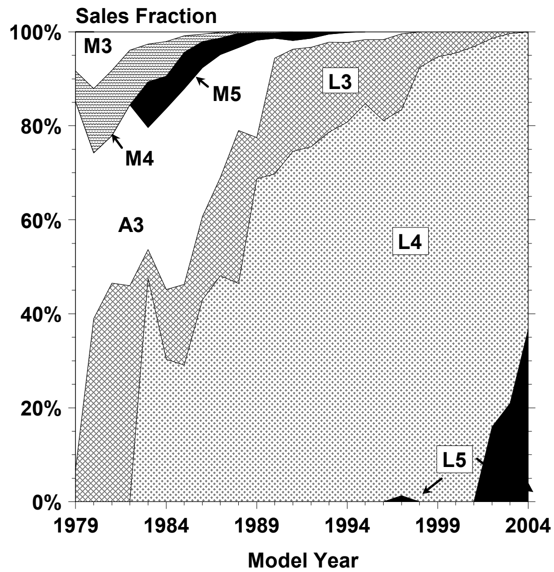


Figure 12

Transmission Sales Fraction

SUVs

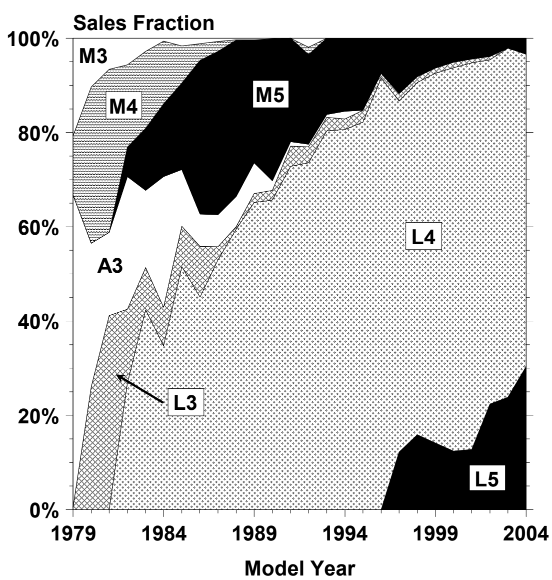


Figure 13

Transmission Sales Fraction

Pickups

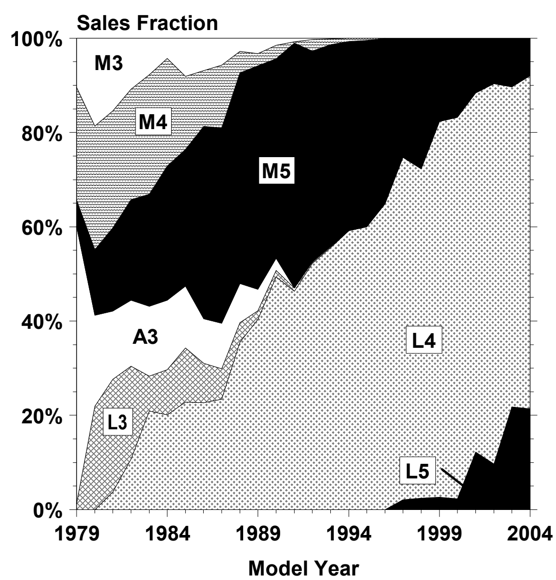


Figure 14

Table 6

Ton-MPG by Transmission and Vehicle Type

	Car		Van		SUV		Pickup	
Trans	2004	1987	2004	1987	2004	1987	2004	1987
M5	44	37	--	37	39	34	39	35
M6	39	--	--	--	40	--	--	--
L3	--	36	--	36	--	31	--	32
L4	43	37	44	36	42	35	43	34
L5	43	--	47	--	41	--	40	--
L6	43	--	--	--	--	--	--	--

A recent powertrain trend has been the development and introduction of CVTs in some vehicle models. These transmissions differ from conventional automatic transmissions and manual transmissions in that CVTs do not have a fixed number of gears. Transmissions alter the ratio of engine speed to drive wheel speed. In conventional transmissions, this speed ratio is limited to a fixed number of discrete values. For a CVT, the ratio is continuous.

In addition to novelty, the advantage of a CVT is that the engine speed/drive wheel speed ratio can be altered to enhance vehicle performance or fuel economy in ways not available with conventional transmissions. Currently, vehicles equipped with CVTs constitute less than two percent of the light-duty vehicle fleet, compared to about one percent last year.

In order to assess the relative efficiency of CVTs compared to conventional transmissions, vehicle models were selected that were available with more than one transmission type. In many cases, the resulting matches turned out to involve vehicles of slightly different weight, which would add additional complexity to an analysis using fuel economy as the variable, so ton-miles per gallon was used as the measure of comparison to account for the weight differences. The Ton-MPG values from the 2004 database were normalized to the values for the M5 transmission, and the results are shown in Table 7.

Table 7 and Figure 15 show that CVTs compared to M5 transmissions on a Ton-MPG basis are lower in Highway Ton-MPG, with city Ton-MPG results both higher and lower in the eight cases in the Table. Resulting 55/45 Ton-MPG values range from 13 percent lower to one percent higher, compared to the M5 transmission, with the average ratio being 0.96.

Table 7

Ton-MPG Ratio to M5

Model Year 2004 Light-Duty Vehicles

		City	Highway	55/45	
Saturn Ion	CVT	0.95	0.87	0.92	
	L5	0.88	0.88	0.88	M5>CVT>L5
	M5	1.00	1.00	1.00	
Saturn Vue	CVT	0.91	0.96	0.93	
	M5	1.00	1.00	1.00	M5>CVT
Mini Cooper	CVT	0.87	0.87	0.87	
	M5	1.00	1.00	1.00	M5>CVT
Civic	CVT	0.96	0.92	0.94	
	M5	1.00	1.00	1.00	M5>CVT
Civic Hybrid	CVT	1.04	0.93	0.99	
	M5	1.00	1.00	1.00	MS=CVT
Civic Hybrid	CVT	1.05	0.94	1.01	
	M5	1.00	1.00	1.00	M5=CVT
Insight Hybrid	CVT	1.05	0.96	1.01	
	M5	1.00	1.00	1.00	M5=CVT
A4	CVT	1.04	0.94	1.00	
	M5	1.00	1.00	1.00	M5=CVT

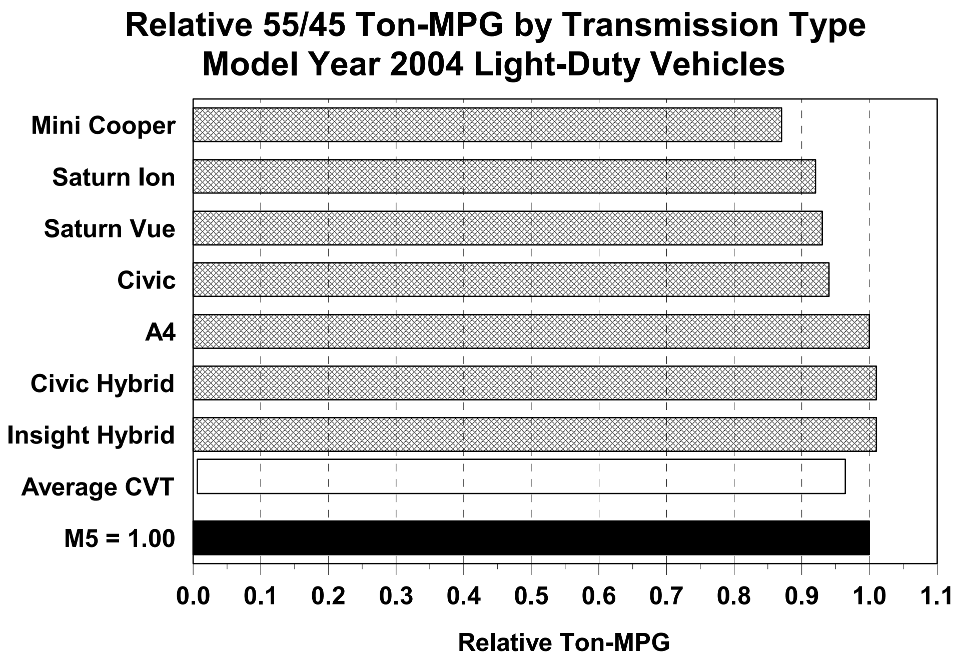


Figure 15

Figures 16 through 19 compare the trends since 1975 for horsepower (HP), displacement (CID), and specific power or horsepower per cubic inch (HP/CID) for cars, vans, SUVs, and pickups. For all four vehicle types, significant CID reductions occurred in the late 1970s and early 1980s. Since 1985, however, engine displacement has been flat for cars and vans but has increased for SUVs and particularly for pickups. Average horsepower has increased substantially for all of these vehicle types since 1981 with the highest increase occurring for pickups whose HP is now almost double what it was then.

Light-duty vehicle engines, thus, have also improved in HP/CID, with engines used in passenger cars improving at a faster rate than truck engines. In fact, for the past several years, car engines have averaged at least 1.0 HP/CID, but vans, SUVs, and pickups have yet to reach the 1.0 HP/CID level.

Car Horsepower, CID and Horsepower per CID

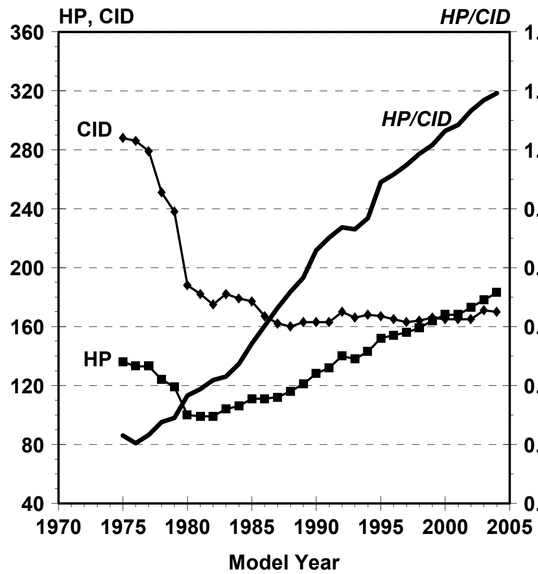


Figure 16

Van Horsepower, CID and Horsepower per CID

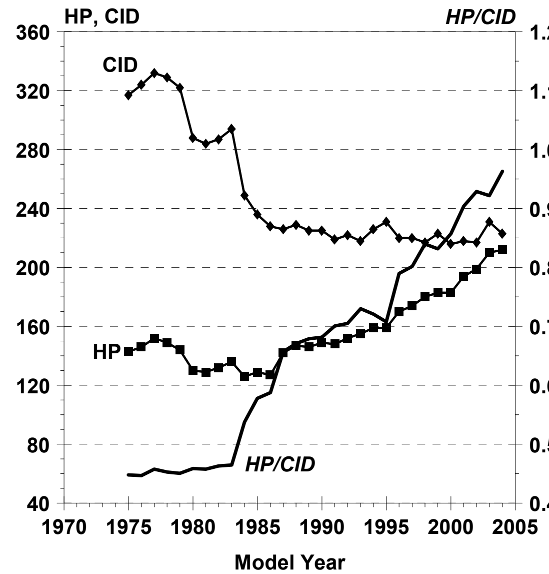


Figure 17

SUV Horsepower, CID and Horsepower per CID

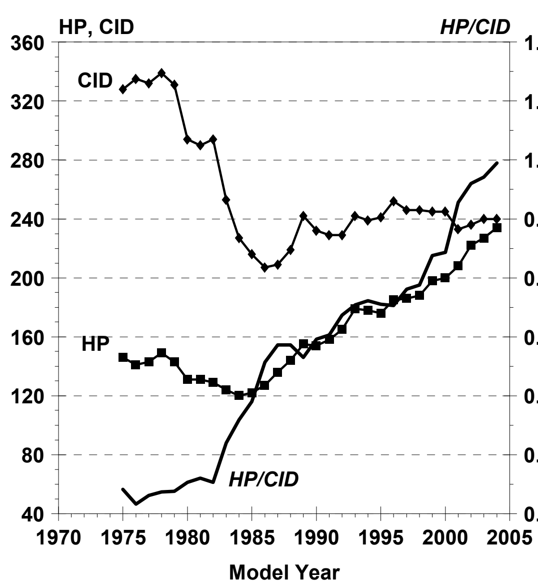


Figure 18

Pickup Horsepower, CID and Horsepower per CID

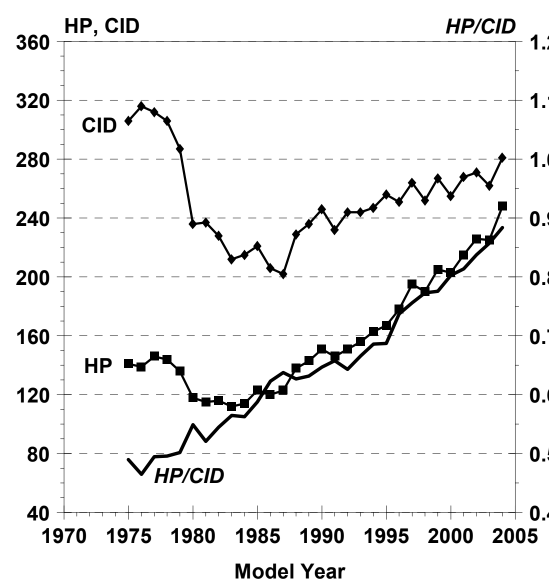


Figure 19

As shown in Table 8, for model year 2004, depending on the vehicle type, truck engines average approximately 16- to 36-percent more horsepower but require about 31- to 65 percent greater displacement, compared to the average passenger-car engine because of the differences in specific power. Note that the specific power of the light-duty fleet now exceeds the 1.0 HP/CID level.

Table 8

MY2004 Engine Characteristics by Vehicle Type

Vehicle Type	HP	CID	HP/ CID	Percent 4 Valve
Car	183	170	1.10	69%
Van	212	223	0.96	44%
SUV	234	240	1.00	57%
Pickup	248	280	0.88	23%
All	208	209	1.03	57%

Table 9 compares CID, HP, and HP/CID by vehicle type and number of cylinders for model years 1987 and 2004. Table 9 shows that the increase in horsepower shown for the fleet in Table 1 extends to all vehicle type and cylinder member strata. All strata show improvements, ranging from 40 percent to 79 percent in horsepower. Because of the less than equal changes in displacement (-7% to 13%), it can be seen that the primary reason for the horsepower increase is increased specific power — up between 33 percent and 92 percent from 1987 to 2004. At the number-of-cylinders level of stratification, model year 2004 cars achieve higher specific power than SUVs, vans, and pickup trucks.

A reason for the lower specific power of some truck engines is that these vehicles may be used to carry heavy loads or pull trailers and thus need more “torque rise,” (i.e., an increase in torque as engine speed falls from the peak power point) to achieve acceptable driveability. Engines equipped with four valves per cylinder typically have inherently lower torque rise than two valve engines with lower specific power.

Table 9

Improvement in Horsepower and Specific Power by Vehicle Type and Number of Cylinders

Vehicle Type	Cyl.	HP 1987	HP 2004	Percent Change	CID 1987	CID 2004	Percent Change	HP/CID 1987	HP/CID 2004	Percent Change
Car	4	92	143	55%	121	126	4%	0.772	1.145	48%
	6	143	208	45%	198	200	1%	0.733	1.047	43%
	8	155	278	79%	299	280	-6%	0.520	0.996	92%
Van	4	100	150	50%	143	148	3%	0.701	1.013	45%
	6	149	209	40%	219	217	-1%	0.703	0.971	38%
	8	167	264	58%	319	312	-2%	0.521	0.845	62%
SUV	4	95	159	67%	127	144	13%	0.755	1.102	46%
	6	138	225	63%	198	221	12%	0.709	1.023	44%
	8	181	280	55%	336	313	-7%	0.537	0.898	67%
Pickup	4	96	150	56%	140	149	6%	0.686	1.003	46%
	6	136	191	40%	222	226	2%	0.637	0.848	33%
	8	169	282	67%	320	319	0%	0.527	0.879	67%

Figures 20 through 23 show that engines with more valves per cylinder deliver higher values of HP per CID. Improvements in HP per CID apply to all of the engines, regardless of the number of valves they have. Engines with *only* two valves per cylinder deliver substantially more horsepower per CID then they used to, typically about a 50 percent increase for the time period shown. The difference in HP and HP-per-CID is because the different vehicle types use different technologies. Figures 24 through 27 show that many cars are equipped with 4-valve engines; the other classes don’t employ this technology as extensively.

HP/CID by Number of Valves Per Cylinder
Cars

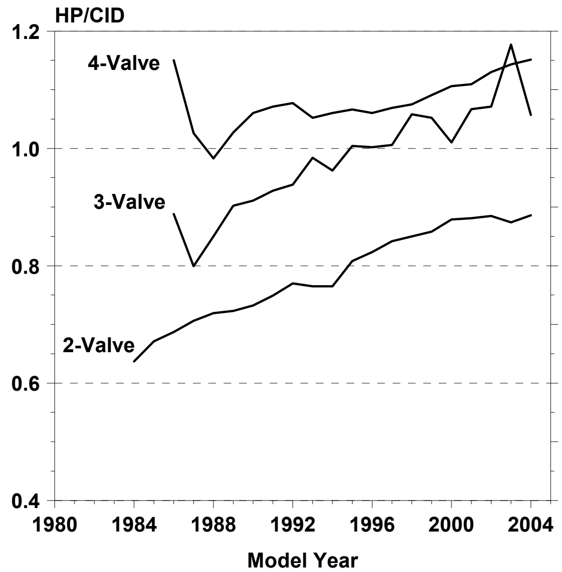


Figure 20

HP/CID by Number of Valves Per Cylinder
Vans

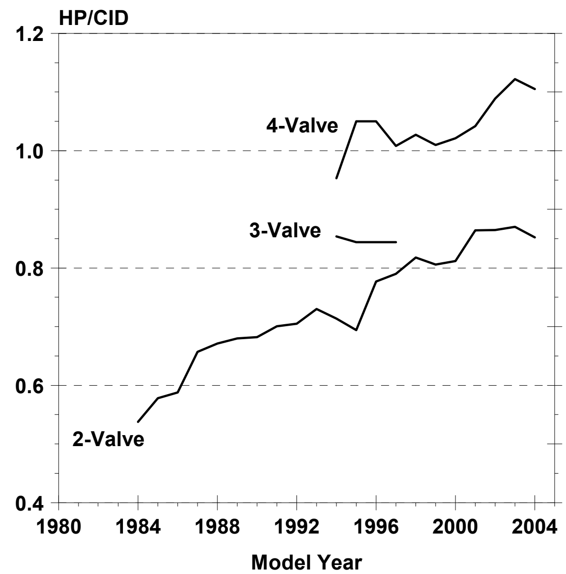


Figure 21

HP/CID by Number of Valves Per Cylinder
SUVs

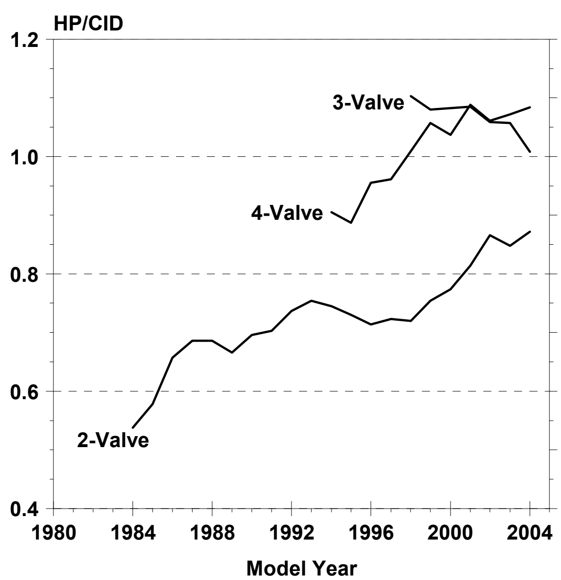


Figure 22

HP/CID by Number of Valves Per Cylinder
Pickups

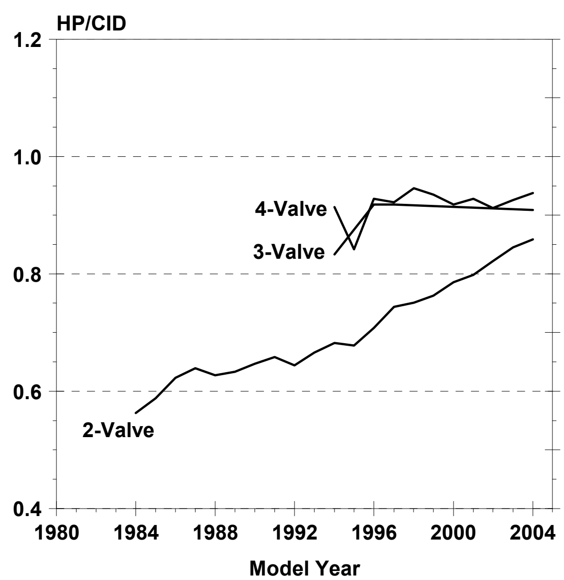


Figure 23

Number of Valves per Cylinder
Cars

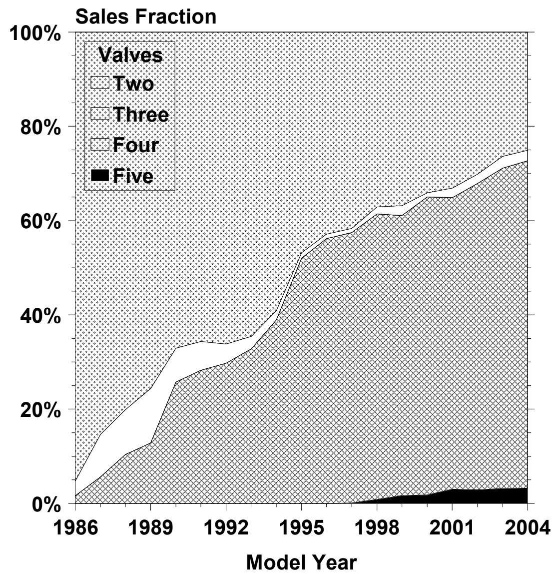


Figure 24

Number of Valves per Cylinder
Vans

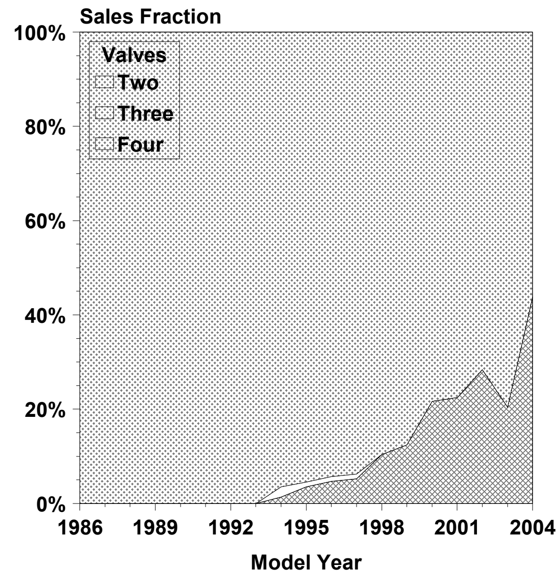


Figure 25

Number of Valves per Cylinder
SUVs

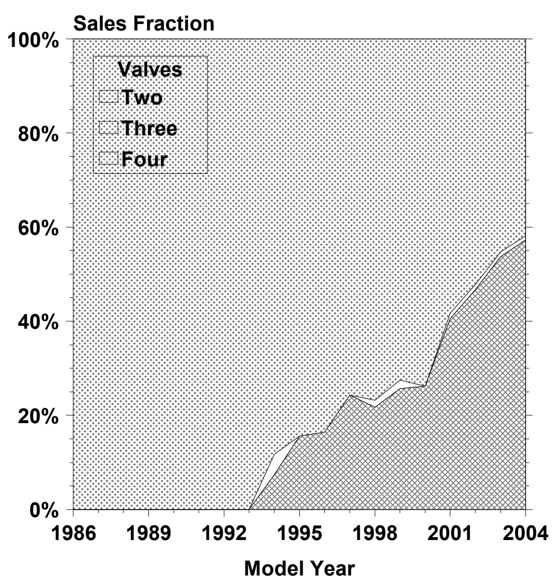


Figure 26

Number of Valves per Cylinder
Pickups

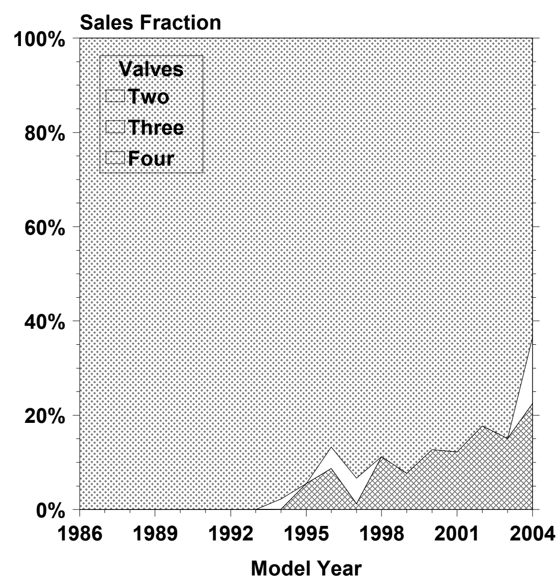


Figure 27

Vehicle performance improvements are due to increases in vehicle power to weight ratio. Obtaining increased power to weight in a time when weight is trending upwards implies that horsepower is increasing faster, which is the case. Increased horsepower can be obtained by increasing the engine's displacement, the engine's specific power (HP/CD), or both. Increasing specific power has been the primary driver for increases in performance for the past two decades.

For the current year fleet, specific power has been studied and engines been classified according to characteristics that exist in the database: (1) by the number of valves per cylinder, (2) by the manufacturer's fuel recommendation, and (3) by the presence or absence of an intake boost device such as a turbocharger or supercharger. Adding the presence or absence of means for varying the engine's valve timing would also be of interest, but the database currently does not include that information.

Figure 28 shows the results for the current fleet. HP/CID is associated with: (a) more valves per cylinder, (b) higher octane fuel, and (c) boost. The technical approaches result in a range from about 0.8 HP/CID to about 1.6 HP/CID.

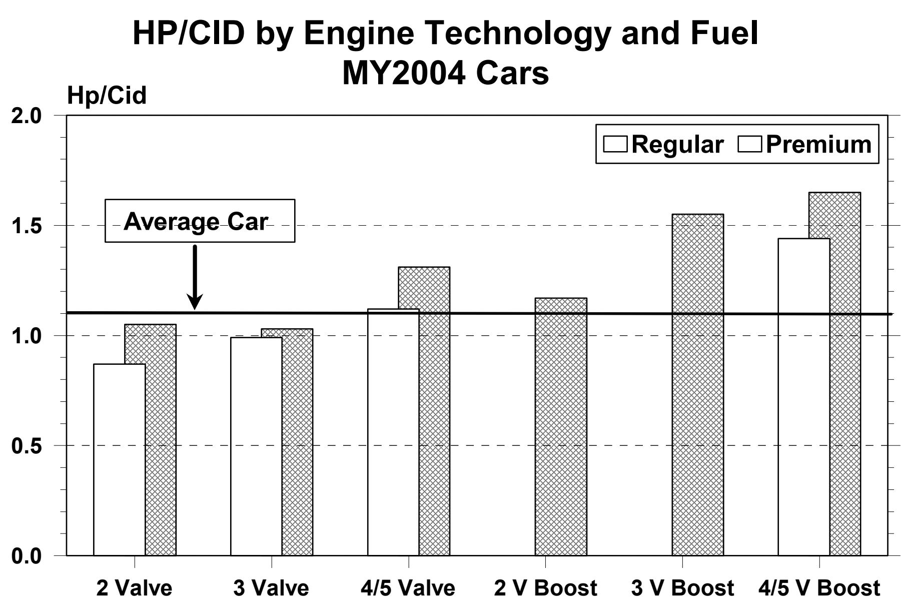


Figure 28

How important each technical option is to the overall fleet HP/CID value is shown in Table 10. The data used for this table and for Figure 28 excludes diesels and hybrids. Table 10 shows the incremental effect, on a sales weighted basis, of adding each technical option. Some of the technical options are not sales significant. The effect of the use of higher octane fuel cannot be discounted, because roughly 20 percent of the current car fleet is comprised of vehicles which use engines for which high octane fuel is recommended. By comparison only seven percent of this year's light trucks use premium fuel.

Engine technology which delivers improved specific power can be used in many ways ranging from reduced displacement and improved fuel economy at constant (or worse) performance, to increased performance and the same fuel economy at constant displacement. As an indication of how the different technologies are used, Figure 29 was generated, which is a plot of fuel economy and performance. The trend line shown reflects the fuel economy/performance tradeoff, on the average. By drawing a vertical line at the average performance, 10.0 seconds, 0-60 time, and a horizontal line at the average MPG, 29.7, the space is divided into four areas of better/worse performance crossed with better/worse fuel economy compared to the averages.

As Figure 29 shows, the technologies shown to result in improved specific power tend to be in the area where the performance is better than the average and the fuel economy is worse than the average, indicating that the technologies are being implemented in the direction of better vehicle performance, not better vehicle fuel economy. In terms of sales, roughly 40 percent of the data is in the Slower/Higher quadrant, 40 percent is in the Faster/Lower quadrant, and 10 percent is in each of the other two quadrants.

Table 10

HP/CID and Sales Fraction by Fuel and Engine Technology

MY2004 Cars

Fuel	Boost	Two		Three		Four/Five		Total
		HP/CID	Sales Fraction	HP/CID	Sales Fraction	HP/CID	Sales Fraction	Sales Fraction
Regular	No Boost	0.87	22.8	0.99	0.0	1.12	56.2	79.0
Premium	No Boost	1.05	0.6	1.03	2.1	1.31	11.2	14.0
Regular	Boost	1.44	0.0	----	0.0	----	0.2	0.2
Premium	Boost	1.17	1.2	1.55	0.1	1.65	4.7	6.1
Other								0.8
Total			24.7		2.3		72.3	100.0

(Column group header: Number of Valves/ Cylinder)

55/45 Laboratory MPG vs 0 to 60 : MY2004 Cars

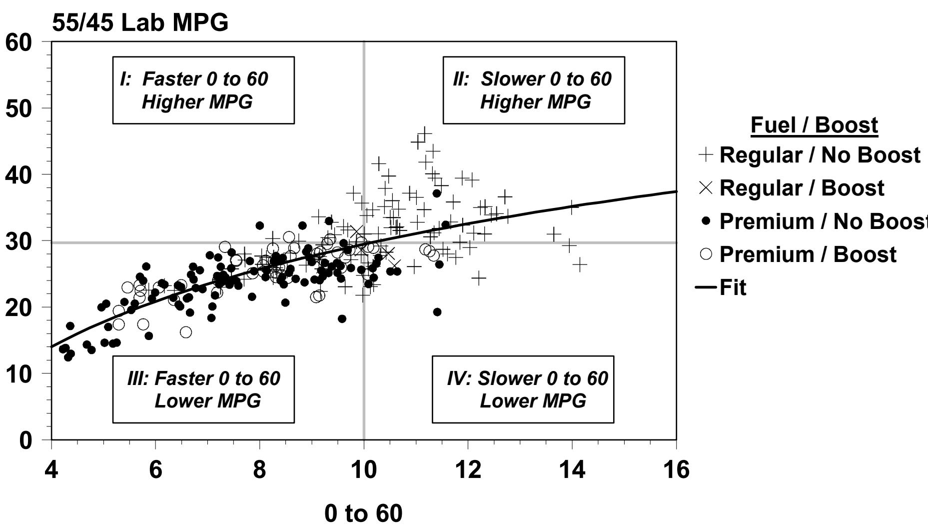


Figure 29

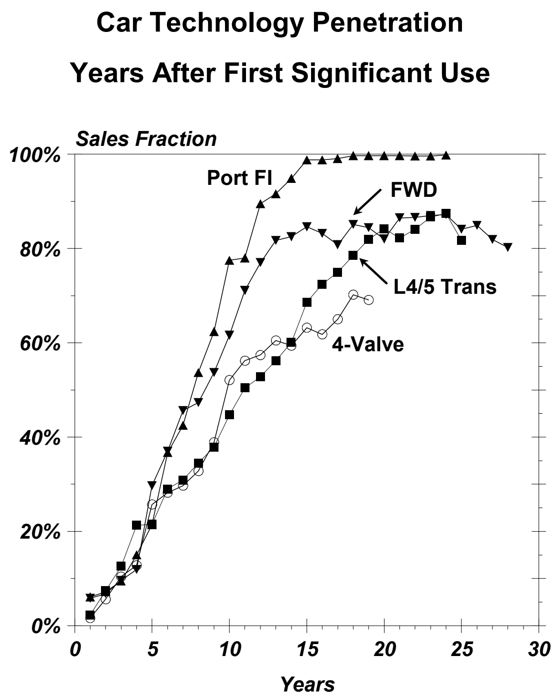


Figure 30

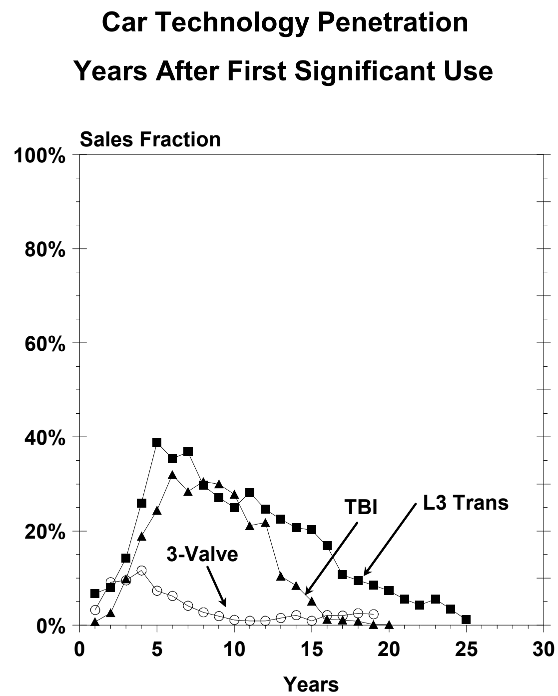


Figure 31

Figure 30 compares penetration rates for four passenger car technologies, namely port fuel injection (Port FI), front-wheel drive (FWD), four valves per cylinder (4-Valve), and four- and five-speed lockup transmissions (L4 and L5). This figure indicates that it may take a decade for a technology to prove itself and attain a sales fraction of 40 to 50 percent and as long as another five or ten years to reach maximum market penetration. It thus takes some time after the introduction of a new technology for it to fully penetrate the market.

A similar comparison of three technologies whose sales fraction peaked out at about 40 percent or less is shown in Figure 31. This figure shows that it often may take a number of years for technologies such as 3-valve-per-cylinder engines (3-valve), throttle body fuel injection (TBI), and lockup 3-speed (L3) transmissions to reach their maximum sales fraction, and, even then, use of these technologies may continue for a decade or longer. For the limited number of cases studied, the time a given technology needs to attain and then pass a market share of about 40 to 50 percent appears to be an indicator of whether it will ever attain a stabilized high level of market penetration.

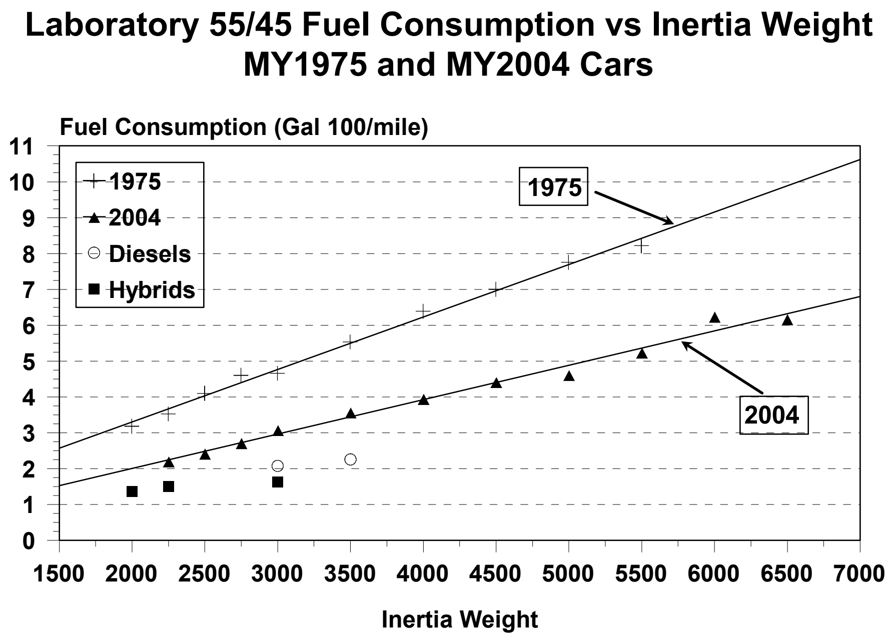


Figure 32

Cars and light trucks with conventional drivetrains have a fuel consumption and weight relationship which is well known and is shown on Figures 32 and 33. Fuel consumption goes up with weight. Vehicles with different propulsion systems, i.e., diesels and hybrids, may occupy a different place on such a fuel consumption and weight plot, as Figure 32 also shows. The lines in Figure 32 were prepared without using the diesel or the hybrid data.

It is likely that vehicles with technology similar to the car diesel and car hybrids currently in the fleet, but differing in weight, would have fuel consumption characteristics in line with the relationships implied by the few data points on Figure 32.

Laboratory 55/45 Fuel Consumption vs Inertia Weight MY1975 and MY2004 Trucks

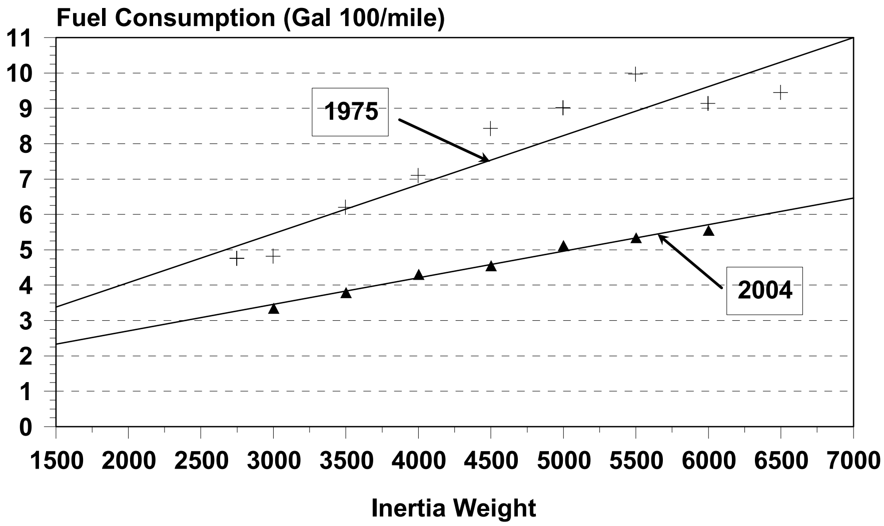


Figure 33

IV. <u>Trends by Vehicle Type and Size Class</u>

Table 1 shows that trucks are expected to account for about 48 percent of light-duty vehicles produced during model year 2004. In the next series of figures and tables, cars and light trucks are classified into five vehicle types: cars (i.e., coupes, sedans, and hatchbacks), station wagons, vans, sports utility vehicles (SUVs), and pickup trucks; and three vehicle sizes: small, midsize, and large. Note that vehicles have not been produced recently in the small van class. Appendixes E and F contains a series of tables describing light-duty vehicles at the vehicle size/type level of stratification in more detail.

Table 11 compares sales fractions by vehicle type and size for model years 1975, 1987, and 2004. Since 1975, the largest increases in sales fraction on this basis have been for midsize and large SUVs. These two classes are expected to account for over 24 percent of the vehicles built this year, compared to a combined total of about 1.3 and 4.2 percent in 1975 and 1987, respectively. Conversely, the largest sales fraction decrease has occurred for small cars which accounted for 40 percent of all light-duty vehicles produced in 1975 and over 43 percent in 1987.

While the small car sales fraction has consistently remained the largest of the 15 vehicle sizes and types, it has since decreased to about 23 percent. An overall decrease has occurred for large cars which accounted for about 15 percent of total light-duty sales in 1975 when they ranked third. Between then and 1987, their sales fraction dropped by about 40 percent.

Considering the five classes: cars, wagons, SUVs, vans, and pickups, since 1975 the biggest increase in market share has been for SUVs, up from less than two percent to more than 26 percent this year, and the biggest decrease has been for cars, down from over 70 percent to less than 50 percent.

Table 12 shows the lowest, average, and highest adjusted MPG performance in the five classes for the three selected years. Improvements in nearly every class are seen from 1975 to 1987. For 2004, the MPG performance is such that the large vehicles in some categories have better fuel economy than the corresponding entry for small vehicles in 1975.

Table 11

Sales Fractions of MY1975, MY1987, and MY2004
Light-Duty Vehicles by Vehicle Size and Type

Vehicle Type	Size	Sales Fraction 1975	1987	2004	Differences in Sales Fraction: From 1975 To 2004	From 1975 To 1987	From 1987 To 2004
Car	Small	40.0%	43.4%	22.9%	-17.1%	3.4%	-20.5%
	Midsize	16.0%	15.2%	15.8%	-0.2%	-0.8%	0.6%
	Large	15.2%	8.2%	9.2%	-6.0%	-7.0%	1.0%
	All	71.2%	66.8%	47.9%	-23.3%	-4.4%	-18.9%
Wagon	Small	4.7%	2.4%	2.3%	-2.4%	-2.3%	-0.1%
	Midsize	2.8%	2.4%	1.0%	-1.8%	-0.4%	-1.4%
	Large	1.9%	0.6%	0.4%	-1.5%	-1.3%	-0.2%
	All	9.4%	5.4%	3.7%	-5.7%	-4.0%	-1.7%
Van	Small	0.0%	0.8%	0.0%	0.0%	0.8%	-0.8%
	Midsize	3.0%	5.7%	6.4%	3.4%	2.7%	0.7%
	Large	1.5%	0.9%	0.6%	-0.9%	-0.6%	-0.3%
	All	4.5%	7.4%	7.0%	2.5%	2.9%	-0.4%
SUV	Small	0.5%	1.7%	1.4%	0.9%	1.2%	-0.3%
	Midsize	1.2%	3.8%	13.6%	12.4%	2.6%	9.8%
	Large	0.1%	0.4%	11.1%	11.0%	0.3%	10.7%
	All	1.8%	5.9%	26.1%	24.3%	4.1%	20.2%
Pickup	Small	1.6%	3.0%	1.1%	-0.5%	1.4%	-1.9%
	Midsize	0.5%	7.1%	2.0%	1.5%	6.6%	-5.1%
	Large	11.0%	4.4%	12.1%	1.1%	-6.6%	7.7%
	All	13.1%	14.5%	15.2%	2.1%	1.4%	0.7%
All	Trucks	19.4%	27.8%	48.3%	28.9%	8.4%	20.5%

Table 12

Lowest, Average, and Highest Adjusted Fuel Economy by Vehicle Type and Size

Vehicle Type	Size	1975 Lowest	1975 Avg.	1975 Highest	1987 Lowest	1987 Avg.	1987 Highest	2004 Lowest	2004 Avg.	2004 Highest
Car	Small	8.6	15.6	28.3	7.5	25.6	55.6	10.6	25.9	62.6
	Midsize	8.6	11.6	18.4	9.1	22.2	27.3	11.8	24.3	55.3
	Large	8.4	11.2	14.6	8.8	20.4	23.6	11.8	22.2	26.1
	All	8.4	13.4	28.3	7.5	24.0	55.6	10.6	24.6	62.6
Wagon	Small	11.8	19.1	24.1	16.7	26.2	33.0	17.2	26.2	40.5
	Midsize	8.4	11.3	25.0	19.1	21.9	27.3	17.8	22.9	28.5
	Large	8.4	10.2	12.8	18.7	19.0	19.1	18.6	18.9	19.1
	All	8.4	13.8	25.0	16.7	23.2	33.0	17.2	24.3	40.5
Van	Small	16.2	17.5	18.5	14.9	20.7	26.1	****	****	****
	Midsize	8.2	11.3	18.4	11.0	18.1	26.2	15.0	20.4	22.1
	Large	8.9	10.7	14.5	10.2	14.5	17.6	14.9	16.2	17.1
	All	8.2	11.1	18.5	10.2	17.8	26.2	14.9	20.0	22.1
SUV	Small	10.2	13.7	16.3	16.7	20.6	28.1	17.6	21.8	26.3
	Midsize	8.2	10.2	18.4	10.1	16.9	28.7	13.3	19.2	25.8
	Large	7.9	10.3	13.7	12.4	14.5	19.5	13.4	16.3	21.9
	All	7.9	11.0	18.4	10.1	17.6	28.7	13.3	17.9	26.3
Pickup	Small	13.0	19.2	20.8	12.8	22.1	27.9	17.3	19.5	24.2
	Midsize	17.8	17.9	18.0	14.4	21.6	36.4	16.4	19.0	25.7
	Large	7.6	11.1	18.5	11.0	15.1	20.5	10.8	16.5	24.1
	All	7.6	11.9	20.8	11.0	19.2	36.4	10.8	17.0	25.7
All	Cars	8.4	13.5	28.3	7.5	24.0	55.6	10.6	24.6	62.6
All	Trucks	7.6	11.6	20.8	10.1	18.4	36.4	10.8	17.9	26.3
All	Vehicles	7.6	13.1	28.3	7.5	22.1	55.6	10.6	20.8	62.6

Table 13

Percent Change in Lowest, Average, and Highest Adjusted Fuel Economy by Vehicle Type and Size

Vehicle		From 1975 to 2004			From 1975 to 1987			From 1987 to 2004		
Type	Size	Lowest	Avg.	Highest	Lowest	Avg.	Highest	Lowest	Avg.	Highest
Car	Small	23%	66%	121%	-12%	64%	96%	41%	1%	13%
	Midsize	37%	109%	201%	6%	91%	48%	30%	9%	103%
	Large	40%	98%	79%	5%	82%	62%	34%	9%	11%
	All	26%	84%	121%	-10%	79%	96%	41%	3%	13%
Wagon	Small	46%	37%	68%	42%	37%	37%	3%	0%	23%
	Midsize	112%	103%	14%	127%	94%	9%	-6%	5%	4%
	Large	121%	85%	49%	123%	86%	49%	0%	0%	0%
	All	105%	76%	62%	99%	68%	32%	3%	5%	23%
Van	Small	***	***	***	-7%	18%	41%	***	***	***
	Midsize	83%	81%	20%	34%	60%	42%	36%	13%	-15%
	Large	67%	51%	18%	15%	36%	21%	46%	12%	-2%
	All	82%	80%	19%	24%	60%	42%	46%	12%	-15%
SUV	Small	73%	59%	61%	64%	50%	72%	5%	6%	-5%
	Midsize	62%	88%	40%	23%	66%	56%	32%	14%	-9%
	Large	70%	58%	60%	57%	41%	42%	8%	12%	12%
	All	68%	63%	43%	28%	60%	56%	32%	2%	-7%
Pickup	Small	33%	2%	16%	-1%	15%	34%	35%	-11%	-12%
	Midsize	-7%	6%	43%	-18%	21%	102%	14%	-11%	-28%
	Large	42%	49%	30%	45%	36%	11%	-1%	9%	18%
	All	42%	43%	24%	45%	61%	75%	-1%	-10%	-28%
All	Cars	26%	82%	121%	-10%	78%	96%	41%	3%	13%
All	Trucks	42%	54%	26%	33%	59%	75%	7%	-2%	-27%
All	Vehicles	39%	59%	121%	0%	69%	96%	41%	-5%	13%

Sales Fraction by Vehicle Type

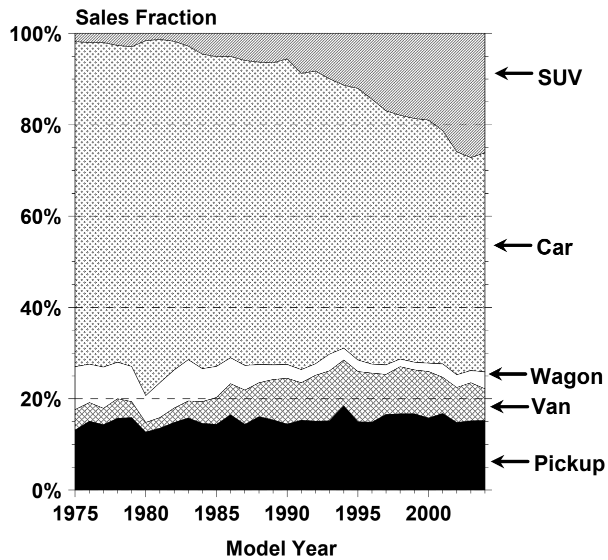


Figure 34

In Table 13, the percentage changes obtainable from the entries in Table 12 are presented. Average MPG for midsize cars and midsize wagons have improved over 100 percent since 1975. Overall, the across-the-board improvements in MPG seen in Table 12 are reproduced here. As shown in Figure 34, the sales fraction for SUVs has increased; the sales fractions for car and wagons declined; that for pickups has remained nearly constant; and vans may be showing a slight decline.

Figure 34 also can be read to show that pickup truck sales fraction has been roughly a constant, and that the combination of wagons and vans has also been roughly a constant for the past two decades. The market dynamic, therefore, has been and is between cars and SUVs with the former dropping in sales fraction and the latter increasing. If the SUV is the new family car, then a case could be made that the market shares for pickups, people movers (vans and wagons) and family cars have not changed much over time.

Figures 35 through 38 show trends in performance, weight, and adjusted fuel economy for cars, vans, SUVs, and pickups. Vehicles continue to get heavier. You have to go back 25 years to 1979 to find a heavier car fleet and this year’s SUV and pickup fleets are the heaviest ever. On the average 2004 cars, vans, SUVs, and pickups are the most powerful and fastest ever. Their respective Ton-MPG values are also the highest.

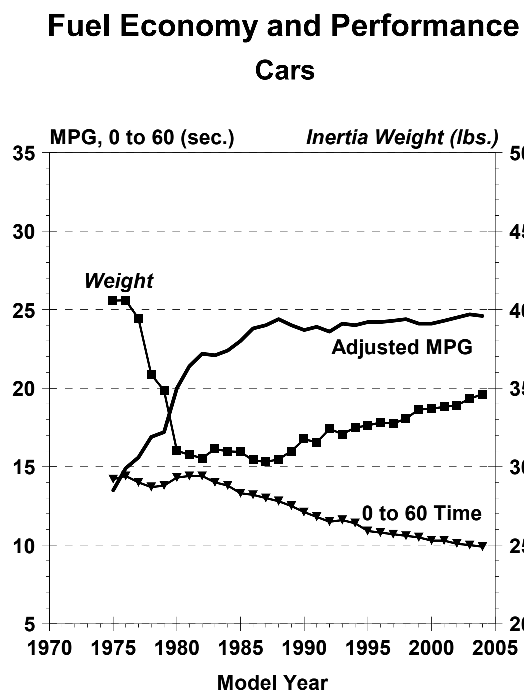


Figure 35

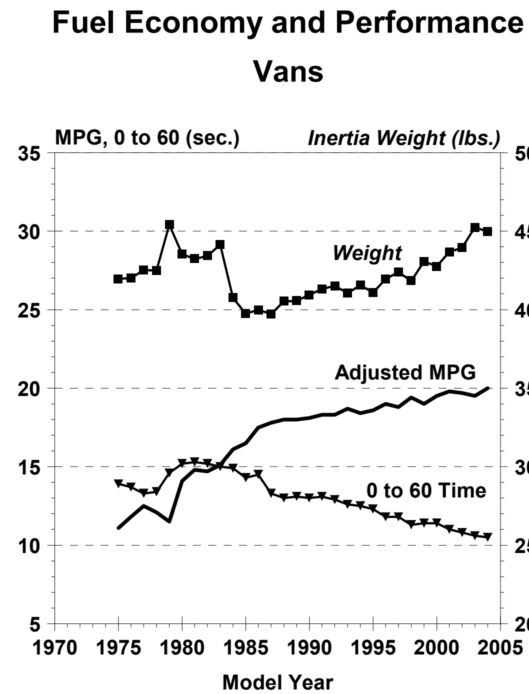


Figure 36

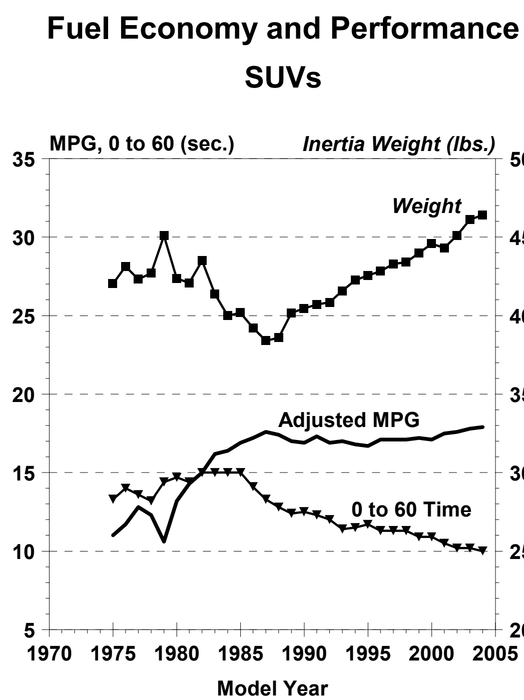


Figure 37

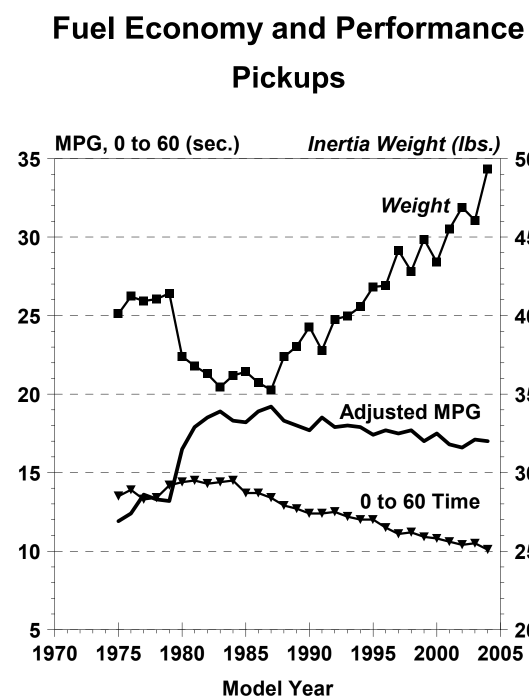


Figure 38

Ton-MPG by Model Year

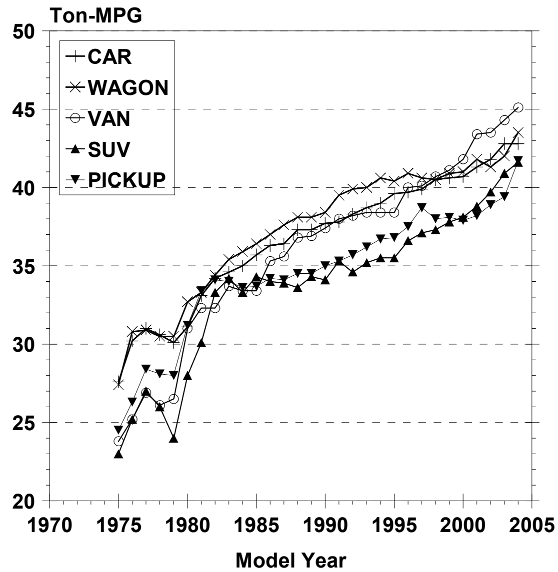


Figure 39

Figure 39 shows the five classes compared on a Ton-MPG basis. In this measure of efficiency, vans lead, cars and wagons are about the same and better than SUVs which are like pickups.

Another way to look at the performance of different types of vehicles is by a classification other than size: weight, for example. In Figures 40 through 43, the four classes of vehicles are shown by weight class. Model years 1975 and 2004 are shown. As with the earlier representation, fuel consumption is plotted versus weight. In each of the four classes, the fuel consumption is lower (better) now than it was in 1975, showing an efficiency improvement for all classes.

Figures 44 through 48 provide an indication of the market share of different weight vehicles within the different classes. Trends within classes are shown which underlie the increasing weight shown by the classes as a whole. Figures 46, 47, and 48 provide a picture of the trends within the light truck class shown on Figure 45.

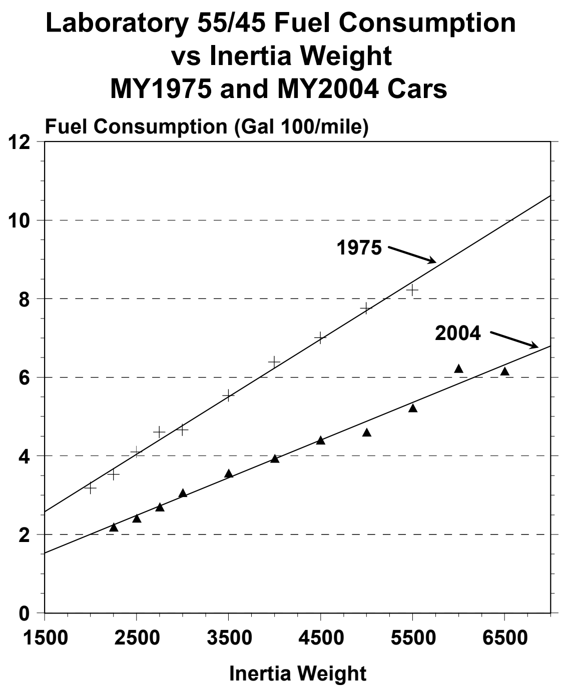


Figure 40

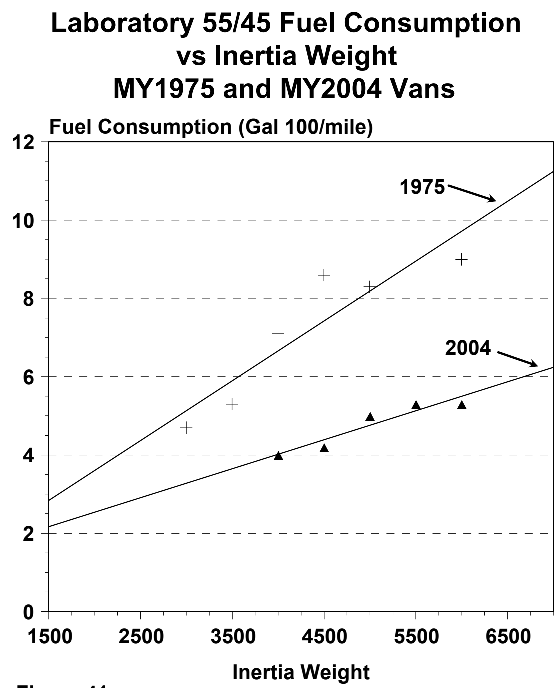


Figure 41

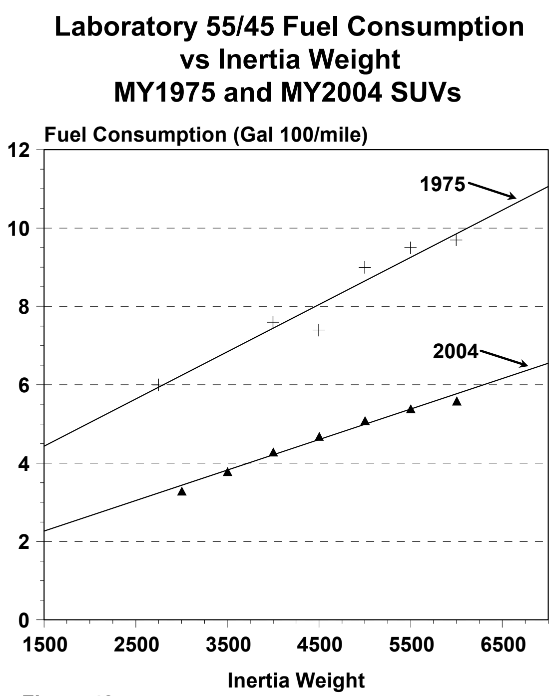


Figure 42

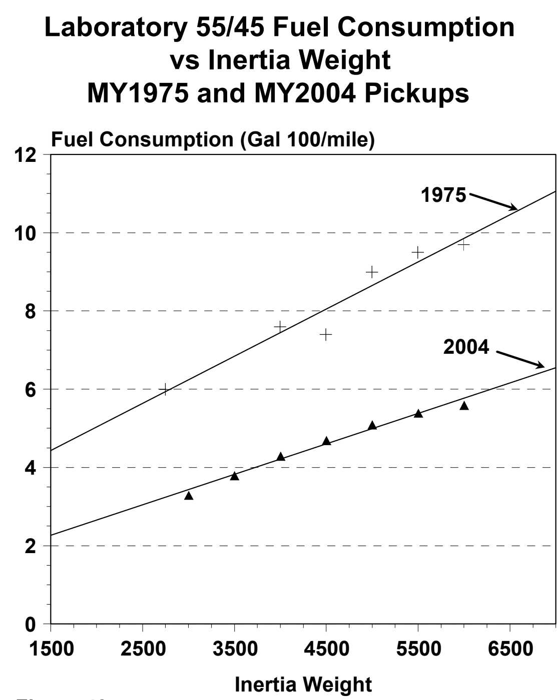


Figure 43

Car Market Share by Inertia Weight Class (Three Year Moving Average)

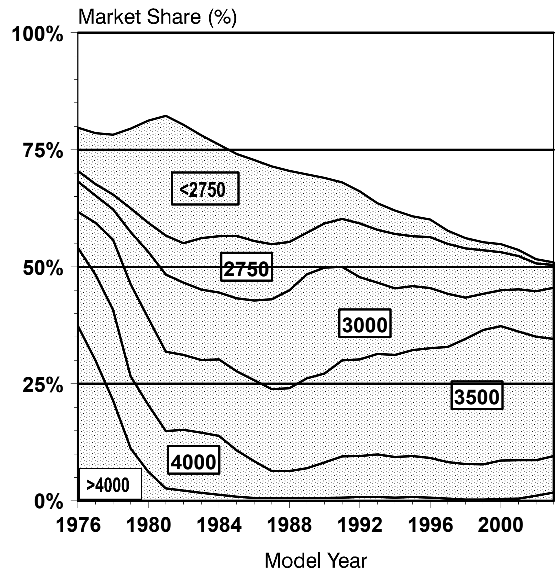


Figure 44

Truck Market Share by Inertia Weight Class (Three Year Moving Average)

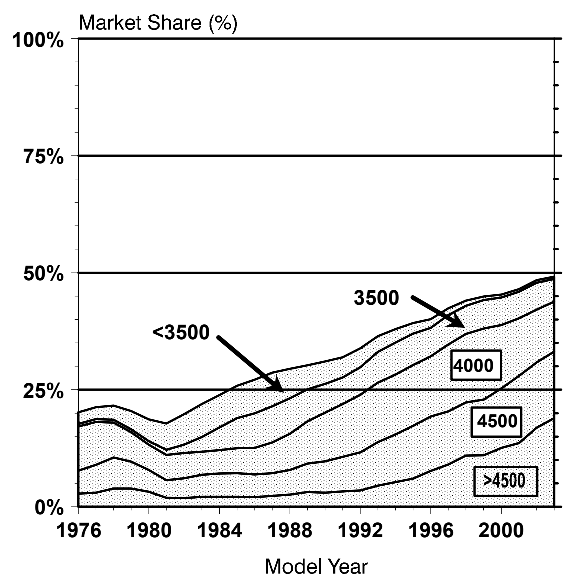


Figure 45

Van Market Share by Inertia Weight Class (Three Year Moving Average)

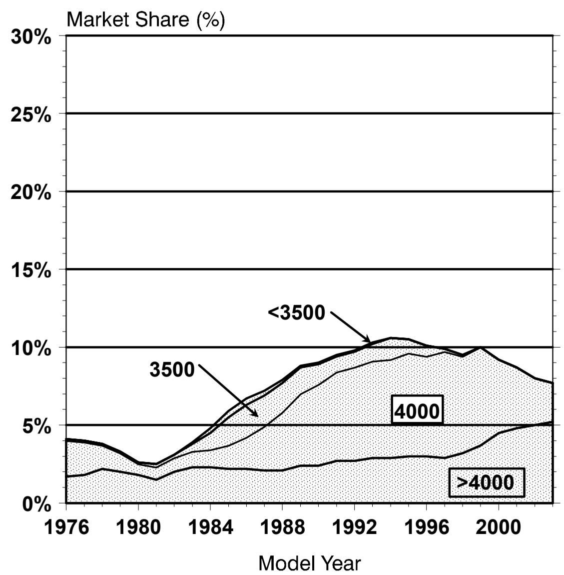


Figure 46

SUV Market Share by Inertia Weight Class (Three Year Moving Average)

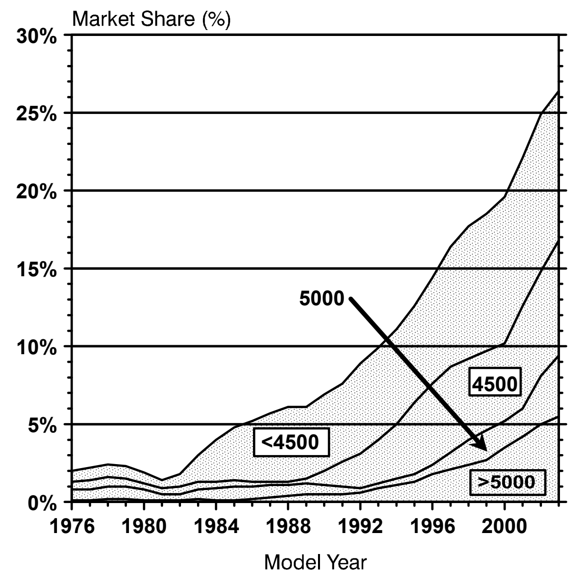


Figure 47

Pickup Market Share by Inertia Weight Class (Three Year Moving Average)

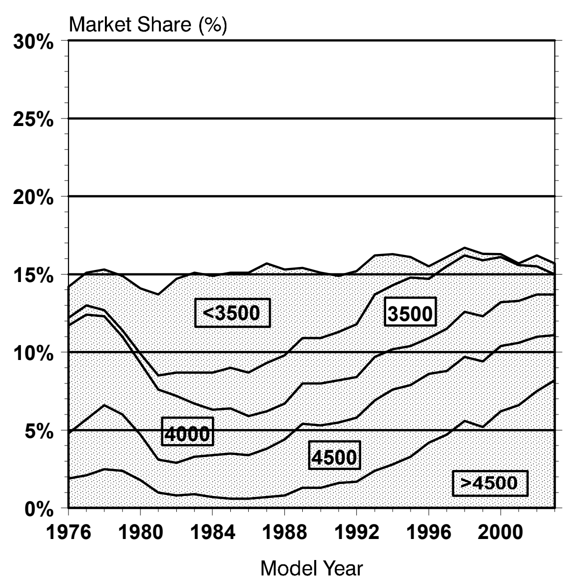


Figure 48

V. Marketing Groups

In its century of evolution, the automotive industry existed first as small, individual companies that relatively quickly went out of business or grew into larger corporations. In that context, the historic term 'manufacturer' usually meant a corporation that was associated with a single country that manufactured vehicles for sale in just that country and perhaps exported vehicles to a few other countries, too. Since the first report in this series was prepared, the nature of the automotive industry has changed substantially, and it has evolved into one in which global consolidations and alliances among heretofore independent manufacturers have become the norm, rather than the exception.

The reports in this series include analyses of fuel economy trends in terms of the whole fleet of cars and light trucks and in various subcategories of interest, e.g., by weight class, by size class, etc. In addition, there has been a treatment of trends by groups of manufacturers. Initially, these groups were derived from the "Domestic" and "Import" categories which are part of the automobile fuel economy standards categories. This classification approach evolved into a market segment approach in which cars were apportioned to a "Domestic," "European," and "Asian" category, with trucks classified as "Domestic" or "Imported." As the automotive industry has become more transnational in nature, this type of vehicle classification has become less useful.

In this report, trends by groups of manufacturers are now used instead of the domestic/imported type grouping to reflect the transnational and transregional nature of the automobile industry. To reflect the transition to an industry in which there are only a small number of independent companies, the fleet has been divided into segments consisting of three multiple partner "marketing groups," four groups with just a few partners, and an eighth catch-all group ("Others") that contains those manufacturers that have not been assigned to one of the seven major marketing groups. Taken together, the seven major marketing groups comprise 97 percent of the MY2004 new vehicle market in the U.S.

The seven major marketing groups used in this report are:

1) The General Motors Group includes GM and those companies which GM owns or has a substantial affiliation with, i.e., Opel, Saab, Isuzu, Fiat, Subaru, Suzuki, and Daewoo;

2) The Ford Motor Group includes Ford, Jaguar, Volvo, Land Rover, Aston Martin, and Mazda;

3) The DaimlerChrysler Group includes Chrysler, Mercedes Benz, Mitsubishi, Hyundai, and Kia;

4) The Toyota Group includes Toyota, Scion and Lexus;

5) The Honda Group includes Honda and Acura;

6) The Nissan Group include Nissan and Infiniti; and

7) The VW Group includes Volkswagen, Audi, SEAT, Skoda, and Bentley.

It is expected that these marketing groups will continue and perhaps expand as further consolidations in the automotive industry occur.

Table 14 compares laboratory fuel economy values for the marketing groups described above for model year 2004 with the overall fleet average. The GM, Ford, and DC Groups are all at or above the fleet average in Percent Truck and below the overall fleet average in MPG, and the Toyota, Honda, and VW Groups are below the fleet average in Percent Truck and are above the overall fleet average in MPG. The Nissan Group is like the GM, Ford, and DC groups on this basis of comparison.

A more detailed comparison of model year 2004 laboratory fuel economy, by vehicle type and size, is presented in Table 15. By marketing group and vehicle type for MY2004, the Honda Marketing Group achieves the highest fuel economy for cars and SUVs and the Toyota Marketing Group for wagons, vans and pickups.

Table 16 is a companion table to Table 15 using adjusted MPG data. More information stratified by marketing group can be found in Appendix M.

Figures 49 through 55 compare model year 1975 to 2004 percent truck, laboratory 55/45 fuel economy for car, trucks, and both cars and trucks for the GM, Ford, DaimlerChrysler, Toyota, Honda, Nissan, and VW marketing groups, respectively. For all seven of these marketing groups, combined car and truck fuel economy is lower now than it was in 1987.

Because the absolute values of fuel economy differ somewhat across the marketing groups, a separate presentation of the fuel economy trends was prepared by normalizing the fuel economy for each Group by the fuel economy in 1987, the year in which MPG for the fleet as a whole was the highest. In this way, a relative measure of how each group, compared to its own value in 1987, can be seen. The results are shown in Figures 56 through 62.

All the marketing groups are lower now than they were in 1987. The declines are very similar, except for the VW Group which has not declined as much, due at least in part to their small light truck share shown on Figure 55.

Table 14

MY2004 Laboratory 55/45 Fuel Economy by Marketing Group

Entire Group Average	**<-- FUEL ECONOMY -->** Cars	Trucks	Both	**Percent Truck**
GM	29.1	20.5	24.1	49%
Ford	25.7	20.1	22.0	59%
DC	27.5	20.9	23.9	48%
Toyota	32.6	22.6	27.0	47%
Honda	32.4	24.6	28.6	42%
Nissan	28.3	21.1	24.1	51%
VW	29.1	19.2	27.8	9%
Others	25.8	20.1	24.0	26%
All/Fleet Average	28.7	20.9	24.4	48%

Table 15

Model Year 2004 Laboratory 55/45 Fuel Economy by Marketing Group

VEHICLE TYPE/SIZE		**GM**	**Ford**	**DC**	**Toyota**	**Honda**	**Nissan**	**VW**	**Others**	**All**
Cars	Small	30.9	27.2	29.0	35.6	37.6	28.8	29.9	26.1	30.3
Cars	Midsize	28.3	25.9	26.7	30.8	29.9	27.6	27.3	25.1	28.4
Cars	Large	27.4	24.0	26.3	27.4	---	---	22.3	23.8	26.0
Cars	All	29.1	25.6	27.8	32.3	32.4	28.3	29.1	25.8	28.8
Wagons	Small	32.2	28.9	27.5	35.8	---	---	31.0	25.8	30.8
Wagons	Midsize	27.7	26.8	23.7	---	---	---	25.8	---	26.8
Wagons	Large	---	---	22.1	---	---	---	---	---	22.1
Wagons	All	30.2	26.8	25.6	35.8	---	---	27.7	25.8	28.5
All Cars	Small	31.0	27.2	28.7	35.7	37.6	28.8	30.0	26.1	30.3
All Cars	Midsize	28.3	26.1	26.6	30.8	29.9	27.6	26.9	25.1	28.3
All Cars	Large	27.4	24.0	25.1	27.4	---	---	22.3	23.8	25.8
All Cars	All	29.1	25.7	27.5	32.6	32.4	28.3	29.0	25.8	28.7
Vans	Small	---	---	---	---	---	---	---	---	---
Vans	Midsize	23.9	22.3	23.6	25.6	24.2	24.7	---	---	23.9
Vans	Large	19.1	18.9	---	---	---	---	---	---	19.0
Vans	All	22.7	21.7	23.6	25.6	24.2	24.7	---	---	23.4
SUVs	Small	25.9	---	21.0	29.6	---	---	---	---	25.6
SUVs	Midsize	23.6	20.7	22.0	23.3	24.7	22.0	---	21.8	22.5
SUVs	Large	19.4	18.4	18.3	17.8	---	19.3	19.2	19.5	19.1
SUVs	All	20.3	19.7	21.1	23.0	24.7	21.1	19.2	20.1	21.0
Pickups	Small	26.4	---	---	22.4	---	---	---	---	23.0
Pickups	Midsize	22.1	22.9	21.0	---	---	---	---	---	22.3
Pickups	Large	19.7	19.3	18.2	18.6	---	19.7	---	---	19.3
Pickups	All	20.0	20.0	18.9	20.4	---	19.7	---	---	19.9
Trucks	All	20.5	20.1	20.9	22.6	24.6	21.1	19.2	20.1	20.9
All	All	24.1	22.0	23.9	27.0	28.6	24.1	27.7	24.0	24.4

Table 16

Model Year 2004 In-use Adjusted 55/45 Fuel Economy by Marketing Group

VEHICLE TYPE/SIZE		GM	Ford	DC	Toyota	Honda	Nissan	VW	Others	All
Cars	Small	26.5	23.3	24.7	30.4	32.1	24.6	25.5	22.4	25.9
Cars	Midsize	24.3	22.2	22.8	26.3	25.6	23.6	23.4	21.6	24.3
Cars	Large	23.5	20.5	22.5	23.4	---	---	19.1	20.4	22.2
Cars	All	24.9	21.9	23.8	27.6	27.7	24.2	24.9	22.1	24.6
Wagons	Small	27.4	24.7	23.5	30.5	---	---	26.5	22.1	26.2
Wagons	Midsize	23.7	22.8	20.3	---	---	---	22.1	---	22.9
Wagons	Large	---	---	18.9	---	---	---	---	---	18.9
Wagons	All	25.8	22.9	21.8	30.5	---	---	23.7	22.1	24.3
All Cars	Small	26.6	23.3	24.5	30.4	32.1	24.6	25.6	22.4	25.9
All Cars	Midsize	24.2	22.3	22.8	26.3	25.6	23.6	23.0	21.6	24.2
All Cars	Large	23.5	20.5	21.5	23.4	---	---	19.1	20.4	22.1
All Cars	All	24.9	22.0	23.5	27.8	27.7	24.2	24.8	22.1	24.6
Vans	Small	---	---	---	---	---	---	---	---	---
Vans	Midsize	20.5	19.1	20.2	21.9	20.7	21.1	---	---	20.4
Vans	Large	16.3	16.1	---	---	---	---	---	---	16.2
Vans	All	19.4	18.6	20.2	21.9	20.7	21.1	---	---	20.0
SUVs	Small	22.1	---	17.9	25.2	---	---	---	---	21.8
SUVs	Midsize	20.2	17.7	18.8	19.9	21.1	18.8	---	18.7	19.2
SUVs	Large	16.6	15.7	15.6	15.2	---	16.5	16.4	16.7	16.3
SUVs	All	17.3	16.9	18.0	19.6	21.1	18.0	16.4	17.2	17.9
Pickups	Small	22.5	---	---	19.1	---	---	---	---	19.5
Pickups	Midsize	18.8	19.6	18.0	---	---	---	---	---	19.0
Pickups	Large	16.8	16.4	15.5	15.8	---	16.8	---	---	16.5
Pickups	All	17.1	17.0	16.1	17.4	---	16.8	---	---	17.0
Trucks	All	17.5	17.1	17.8	19.2	21.0	18.0	16.4	17.2	17.9
All	All	20.6	18.8	20.4	23.0	24.4	20.6	23.7	20.6	20.8

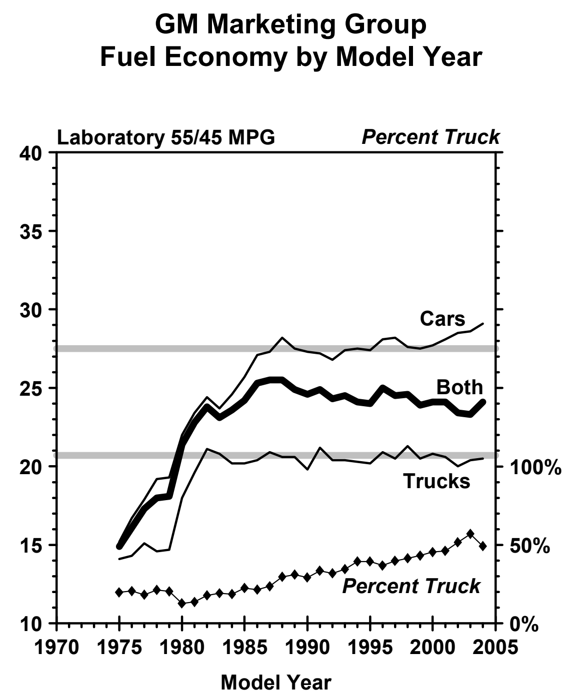


Figure 49

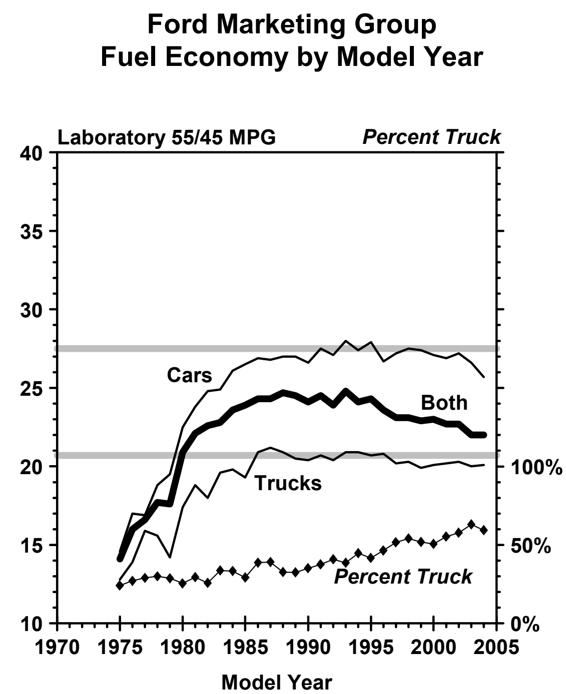


Figure 50

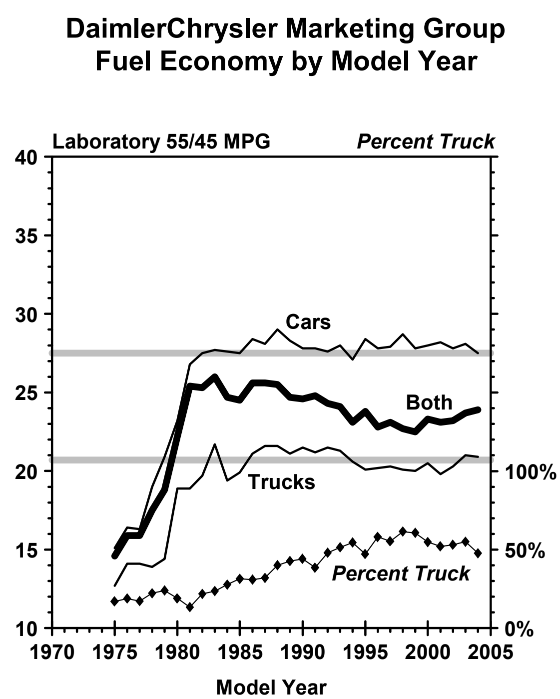


Figure 51

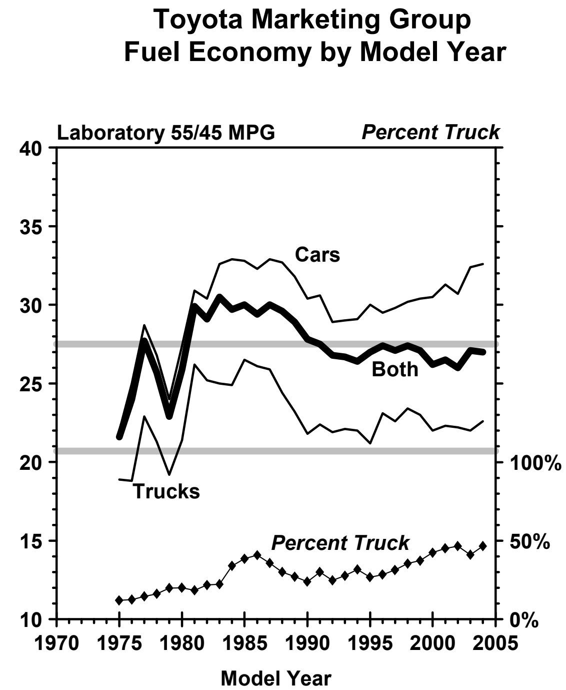
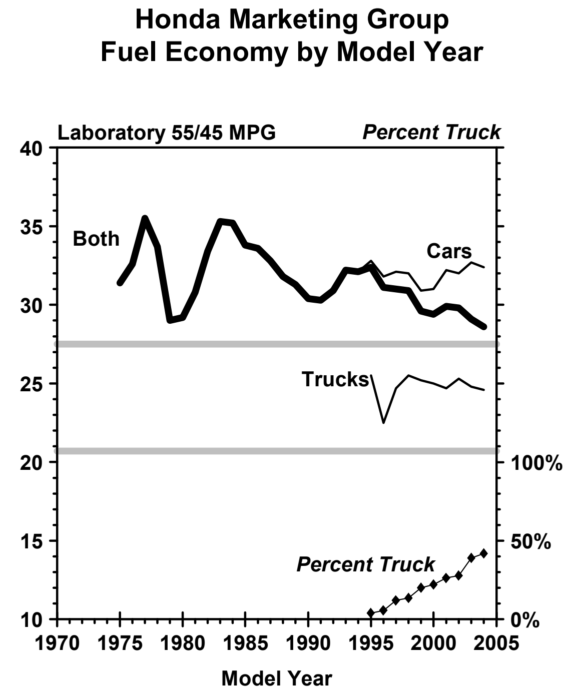


Figure 52



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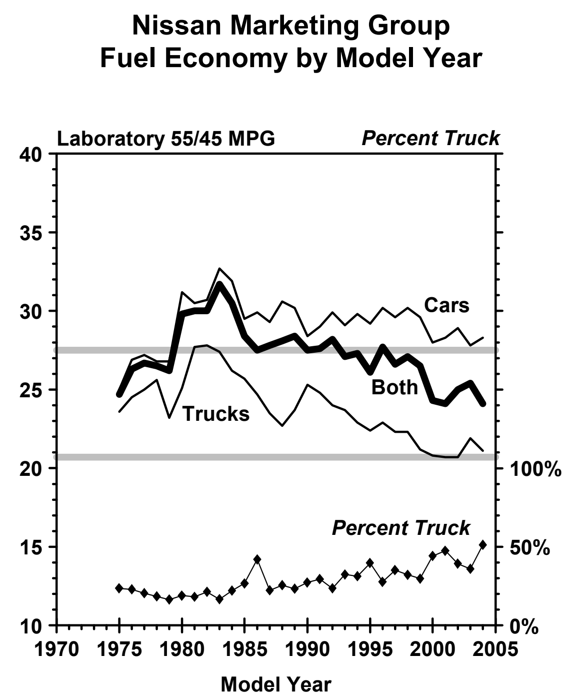

Figure 54

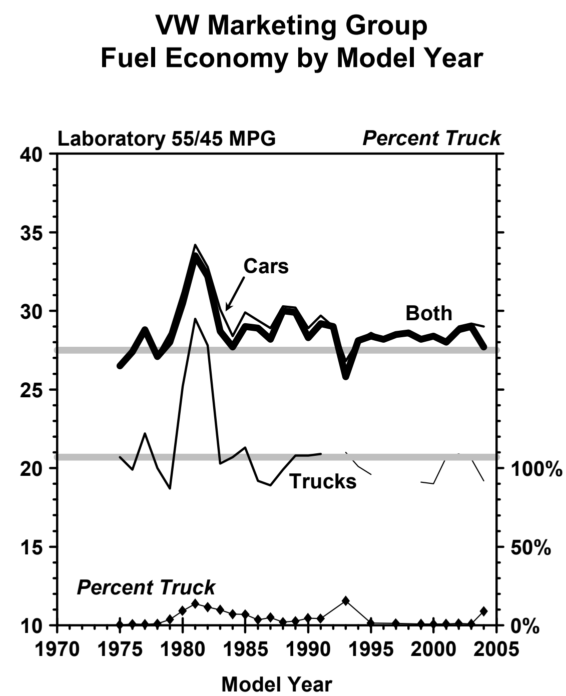

Figure 55

Normalized Fuel Economy
GM Marketing Group

(Both Cars and Trucks)

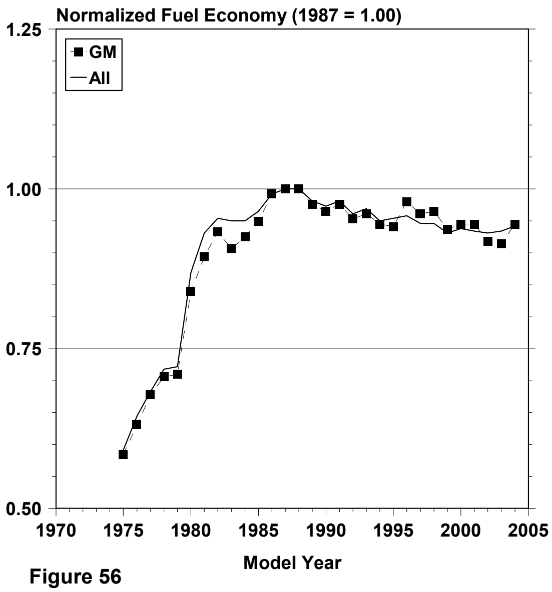

Figure 56

Normalized Fuel Economy
Ford Marketing Group

(Both Cars and Trucks)

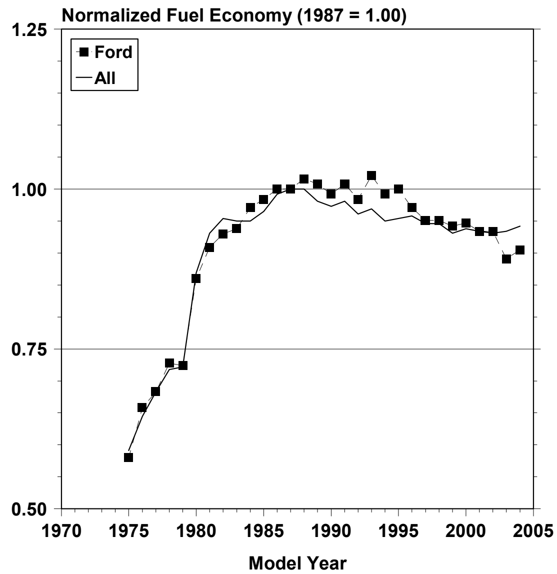

Figure 57

Normalized Fuel Economy
DC Marketing Group

(Both Cars and Trucks)

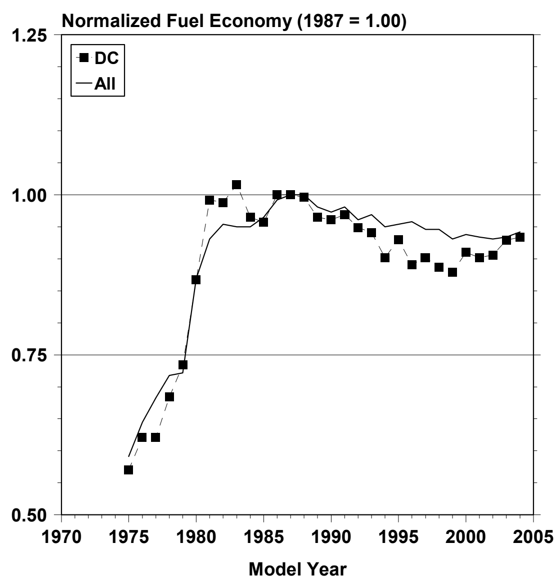

Figure 58

Normalized Fuel Economy Toyota Marketing Group

(Both Cars and Trucks)

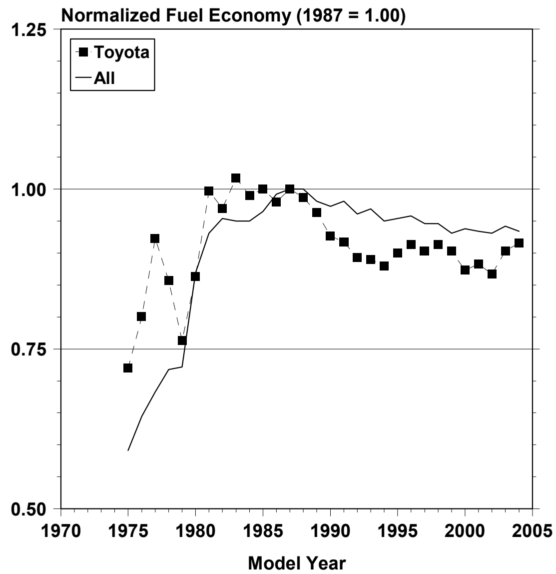

Figure 59

Normalized Fuel Economy Honda Marketing Group

(Both Cars and Trucks)

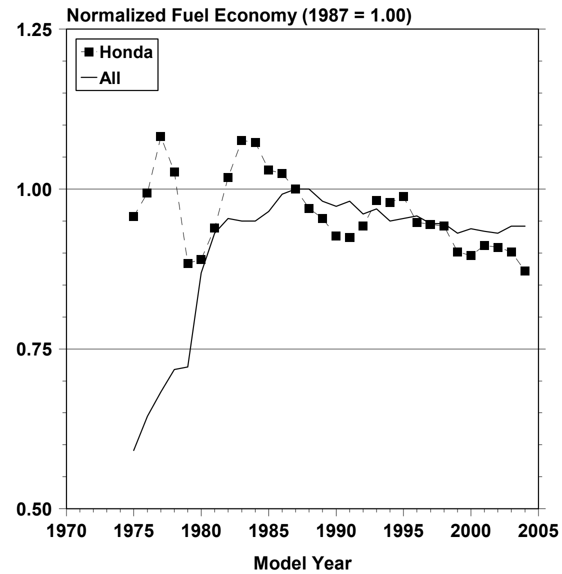

Figure 60

Normalized Fuel Economy Nissan Marketing Group

(Both Cars and Trucks)

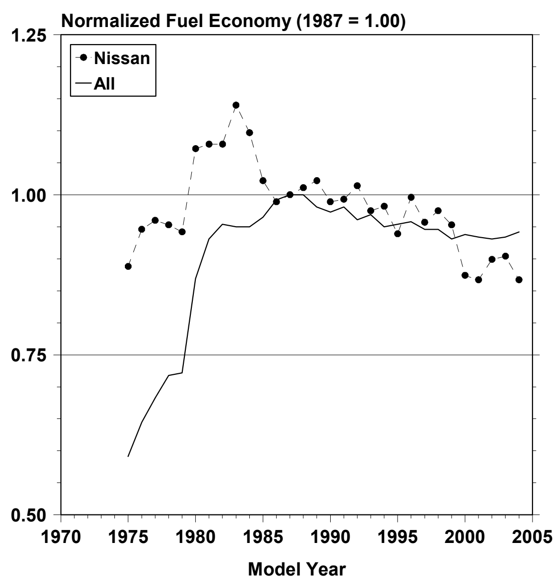

Figure 61

Normalized Fuel Economy VW Marketing Group

(Both Cars and Trucks)

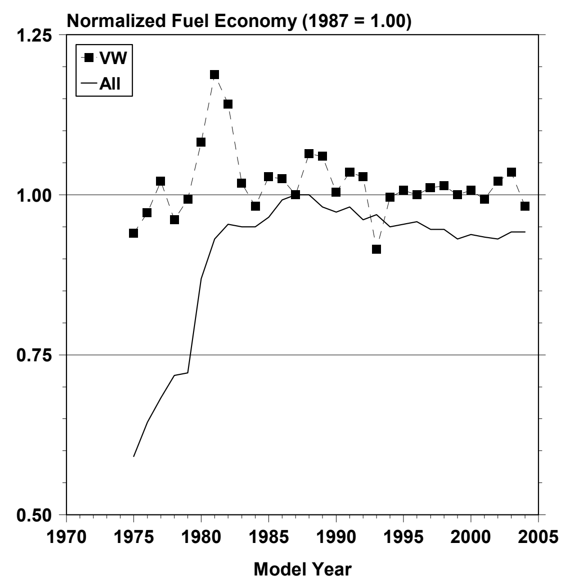

Figure 62

VI. Characteristics of Fleets Comprised of Existing Fuel-Efficient Vehicles

This section is limited to a discussion of hypothetical fleets of vehicles comprised of fuel-efficient vehicles and the fuel economy and other characteristics of those fleets.

This section includes a discussion of some of the technical and engineering factors that affect fleet fuel economy. It does not attempt to evaluate either the benefits or the costs of achieving various fuel economy levels. In addition, the analysis presented here also does not attempt to evaluate the marketability or the public acceptance of any of the hypothetical fleets that result from the scenarios studied and discussed below.

As stated earlier in this report, the fuel economy of the combined car and light truck fleet has decreased from a peak value achieved in 1987 with much of this decline attributable to the increased market share of light trucks.

There are several different ways to look at the potential for improved fuel economy from the light-duty vehicle fleet. Many of these approaches utilize projections of more fuel efficient technologies that are not in the fleet today. As an example, a fleet made up of a large fraction of fuel cell vehicles could be considered. Such projections can be associated with a good deal of uncertainty, since uncertainty in the projections of market share compound with uncertainties about the fuel economy performance of yet uncommercialized technology. These uncertainties can be thought of as a combination of technical risk, i.e., can the technology be developed and mass produced?, and market risk, i.e., will people buy vehicles with the improved fuel economy?

One general approach used in this report is to consider only the fuel economy performance of those technologies which exist in today's fleet. This eliminates uncertainty about the feasibility and production readiness of the technology and reduces or eliminates the technical risk but does not treat market risk, as mentioned above. Therefore, the analysis can be thought of as the fuel economy potential now in the fleet, with no new technologies added, if the higher MPG choices available were to be selected.

There is a wide distribution of fuel economy. Because of the interest in the high end of this spectrum, this portion of the database was examined in more detail using a "best in class" (BIC) technique. The BIC analysis is not new, in fact it was one of the methods used to investigate future fleet MPG capability when the original fuel economy standards were set.

In any group or class of vehicles there will be a distribution of MPG performance, and the "best in class" method relies on that fact. The analysis involves dividing the fleet of vehicles into classes, selecting a set of representative high MPG "role model" vehicles from each class, and then calculating the average characteristics of the resultant fleet using the same relative sales proportions as in the baseline fleet.

One potential problem with a BIC analysis is that the high MPG cars used in the analysis may be unusual in some way — so unusual that the hypothetical fleet made up of them may be deficient in some other attributes considered desirable by vehicle buyers. Because the BIC analysis is also sensitive to the selection of the best vehicles, three different procedures were used to select the role models.

Two of these selection procedures use the EPA car size classes (which for cars are the same as those used for the EPA/DOE *Fuel Economy Guide*) and the truck type/size classes described previously in this report. Note that this classification system includes nine car and nine truck classes and, for this model year, one of these eighteen classes is not represented (Small Vans). The third best-in-class role model selection procedure is based on using the vehicle inertia weight classes used for EPA's vehicle testing and certification process.

The advantage of using and analyzing data from the best-in-size class methods is that if the sales proportions of each class are held constant, the sales distribution of the resultant fleet by *vehicle type and size* does not change. This means that the size of the average vehicle does not change a lot. Similarly, there also is an advantage in using the inertia weight classes to determine the role models, since, if the sales proportions in each inertia weight class are held constant, the sales distribution of the resultant fleet by *weight* does not change, and in this case, the average weight remains the same.

One way of performing a best-in-class (BIC) analysis is to use as role models the four nameplates with the highest fuel economy in each size class. (See Tables N-1 and N-2 in Appendix N.) Under this procedure, all vehicles in a class with the same nameplate are included as role models regardless of vehicle configuration. Each role model nameplate from each class was assigned the same sales weighting factor, but the original sales weighting distribution for different vehicle configurations within a given nameplate (e.g., transmission type, engine size, and/or drive type) was retained. The resulting values were used to recalculate the fleet average values using the same relative proportions in each of the size classes that constitute the fleet.

In cases where two identical vehicles differ by only one characteristic but have slightly different nameplates (such as the two-wheel drive Chevrolet C1500 and the four-wheel drive Chevrolet K1500 pickups), both are considered to have the same nameplate. Conversely, in the cases where there are technically identical vehicles with different nameplates (e.g., the Buick LeSabre and Pontiac Bonneville sedans), only one representative vehicle nameplate was used in the BIC analysis.

The second best-in-class role model selection procedure involves selecting as role models the best dozen vehicles in each size class with each vehicle configuration considered separately. Tables N-3 and N-4 in Appendix N give listings of the representative vehicles used in this method. As with the previous procedure, in cases where technically identical vehicle configurations have different nameplates, only one representative vehicle was used. Under this best-in-class method, the sales data for each role model vehicle in each class was assigned the same value, and the resulting values were used to re-calculate the fleet values again using the same relative proportions in each of the size classes that constitute the fleet.

The third best-in-class procedure involves selecting as role models the best dozen vehicles in each weight class. As with the previous method, each vehicle configuration was considered separately. (See Tables N-5 and N-6 in Appendix N for a listing of the vehicles used in this analysis.) It should be noted that some of the weight classes have less than a dozen representative vehicles. In addition, as in the previous two best-in-class methods, where technically identical vehicle configurations with different nameplates are used, only one representative vehicle was included. As with the two best-in-size class methods, the sales data for each role model vehicle in each class was assigned the same value, and the resulting values were used to recalculate the fleet values again using the same relative proportions in each of the size classes that constitute the fleet.

Tables 17 to 19 compare, for cars, trucks, and both cars and trucks, respectively, the results of the best-in-class analysis with actual average data for model year 2004. As discussed earlier, for the size class scenarios, the percentage of vehicles that are small, midsize, or large are the same as for the baseline fleet, and in the weight class scenarios, the average weight of the BIC data sets is the same as the actual one. Average interior volume for cars in the BIC weight class analysis is about the same as the overall average (111 vs. 110 cu. ft.).

The small differences in interior volume between the size class scenarios and the actual vehicle fleet can be attributed to the fact that, within a size class, there is considerable variation in interior volume (i.e., not all vehicles in each size class have exactly the same interior volume).

Under all of the best-in-class (BIC) scenarios, the vehicles used for the BIC analysis have less powerful engines, have slower 0-to-60 acceleration times, and are more likely to be equipped with manual transmissions than the entire fleet as a whole. For trucks, the BIC data set vehicles make greater use of front-wheel drive.

For both cars and trucks, the "Best 12 Vehicles" in Size Class scenario results in significantly higher fuel economy than the actual fleet, but the vehicles in the BIC size set are lighter than their counterparts from the other scenarios. Depending on the scenario chosen, for model year 2004, cars could have achieved from 11 to 15 percent better fuel economy than they did. Similarly, trucks could have achieved from 9 to 18 percent better fuel economy, and the combined car and truck fleet could have been 9 to 16 percent better.

The best-in-class analyses can be thought of as the MPG potential now in the fleet with no new technologies added, if the higher MPG choices available were selected. As such, the best-in-class analyses provide a useful reference point indicating the variation in fuel economy levels that result in large part from consumer preferences as opposed to technological availability.

One of the characteristics of the best-in-class analysis is that it typically results in a hypothetical fleet of vehicles which has a larger fraction of manual transmissions than today's fleet does. This is a consequence of the methodology. There has been some discussion of the practicality of such a fleet of vehicles, especially for the U.S. market, where automatic transmissions dominate, and have done so for several years.

Another general approach for determining potential fuel economy improvement is to study the relationships between vehicle technology improvements, vehicle acceleration times, vehicle size, and vehicle weight.

Table 17

Best in Class Results: Model Year 2004 Cars

Vehicle Characteristic	Selection Basis	Actual Data	Size Class	Size Class	Weight Class
	Selection Criteria	All Cars	Best 4 Nameplates	Best 12 Vehicles	Best 12 Vehicles
Percent of Car	Fleet Included	100%	28%	35%	18%
Fuel Economy	Lab. 55/45	28.7	32.9	32.8	32.0
	Adjusted City	21.6	24.8	24.8	24.2
	Adjusted Highway	29.6	33.5	33.3	32.6
	Adjusted 55/45	24.6	28.1	28.0	27.4
Vehicle Size	Weight (lb)	3462	3122	3171	3462
	Volume (Cu. Ft.)	110	108	109	111
Engine	CID	170	139	139	144
	HP	183	155	149	163
	HP/CID	1.096	1.135	1.099	1.145
	HP/Wt	0.0521	0.0490	0.0467	0.0466
	Pct. Four Valve/Cyl.	69%	86%	82%	94%
Performance	0 to 60 Time (sec.)	9.9	10.3	10.6	10.6
	Top Speed (mph)	133	127	125	126
	Ton-MPG	42.9	44.1	44.6	47.4
	Cu. Ft. MPG	2766	3071	3099	3069
	Cu. Ft. Ton-MPG	4743	4771	4888	5261
Drive	Front	80%	96%	96%	91%
	Rear	15%	3%	2%	3%
	Four Wheel	5%	1%	2%	6%
Transmission	Lockup	85%	83%	85%	81%
	Manual	13%	14%	12%	19%

Table 18

Best in Class Results: Model Year 2004 Trucks

Vehicle Characteristic	Selection Basis	Actual Data	Size Class	Size Class	Weight Class
	Selection Criteria	All Truck	Best 4 Nameplates	Best 12 Vehicles	Best 12 Vehicles
Percent of Truck Fleet Included		100%	30%	21%	30%
Fuel Economy	Lab. 55/45	20.9	23.4	24.6	22.8
	Adjusted City	16.0	18.0	18.9	17.4
	Adjusted Highway	20.8	23.0	24.1	22.6
	Adjusted 55/45	17.9	19.9	21.0	19.4
Vehicle Size	Weight (lb)	4712	4233	4063	4712
Engine	CID	251	208	193	228
	HP	235	210	194	229
	HP/CID	0.955	1.038	1.028	1.028
	HP/Wt	0.0498	0.0491	0.0473	0.0483
	Pct. Four Valve/Cyl.	44%	60%	66%	65%
Performance	0 to 60 Time (sec.)	10.1	10.2	10.5	10.3
	Top Speed (mph)	137	133	130	135
	Ton-MPG	42.1	42.3	42.6	45.7
Drive	Front	19%	28%	35%	37%
	Rear	32%	22%	32%	19%
	Four Wheel	50%	50%	33%	44%
Transmission	Lockup	89%	90%	85%	93%
	Manual	4%	7%	11%	5%

Table 19

Best in Class Results: Model Year 2004 Light-Duty vehicles

Vehicle Characteristic	Selection Basis	Actual Data	Size Class	Size Class	Weight Class
	Selection Criteria	All Vehicles	Best 4 Nameplates	Best 12 Vehicles	Best 12 Vehicles
Fuel Economy	Lab. 55/45	24.4	27.3	28.2	26.7
	Adjusted City	18.5	20.9	21.6	20.3
	Adjusted Highway	24.6	27.3	28.1	26.9
	Adjusted 55/45	20.8	23.3	24.1	22.8
Vehicle Size	Weight (lb)	4066	3677	3602	4066
	Volume (Cu. Ft.)				
Engine	CID	209	173	165	184
	HP	208	182	171	195
	HP/CID	1.028	1.087	1.065	1.088
	HP/Wt	0.0510	0.0490	0.0470	0.0474
	Pct. Four Valve/Cyl.	57%	73%	74%	80%
Performance	0 to 60 Time (sec.)	10.0	10.3	10.5	10.5
	Top Speed (mph)	135	130	127	130
	Ton-MPG	42.5	43.2	43.6	46.6
Drive	Front	50%	63%	67%	65%
	Rear	23%	12%	16%	11%
	Four Wheel	27%	25%	17%	24%
Transmission	Lockup	87%	87%	85%	87%
	Manual	9%	10%	12%	12%

Table 20 shows the results of comparisons of this year's fleet to the fleets of the baseline years 1981 and 1987. These comparisons were made using the characteristics of vehicles with conventional drive trains, i.e., excluding hybrids and diesels.

Table 20

Laboratory Fuel Economy, Inertia Weight, and 0-to-60 Time For Three Model Years

Vehicle Type	Model Year	55/45 MPG	Inertia Weight	0-to-60 Time
Cars	1981	25.1	3075	14.4
	1987	28.1	3030	13.0
	2004	28.7	3462	9.9
Trucks	1981	20.1	3805	14.6
	1987	21.6	3712	13.3
	2004	20.9	4712	10.1
Both Cars and Trucks	1981	24.1	3201	14.4
	1987	25.9	3220	13.1
	2004	24.4	4066	10.0

The comparisons are made by preserving the efficiency characteristics of today's fleet but re-mixing it to reflect the sales distribution by the size, or weight, or performance characteristics of the baseline year. In the table these distributions are referred to as "mixes," so that "1987 Wt. Mix" means the sales distribution by weight class of the 1987 fleet.

Table 21 shows the results of various ways to examine what the fuel economy of the fleet would be if today's fleet of cars and trucks were "like" those of an earlier year in one or more respects. For example, using weight and performance distributions like those of 1981 and 1987 would yield car fuel economy improvements of 29 percent and 20 percent, respectively.

Mixing today's efficiency characteristics with the baseline year's size, weight, and performance distributions shows an improvement over the 2004 actual values in nearly all cases. This is evidence that today's vehicles are more efficient, vehicle for vehicle, than they were in the baseline years – especially evident when the values are compared to the actual values for the base years, shown as "Ref: 1981 Actuals" and "Ref: 1987 Actuals" in the Table, for which every re-mixed value shows an improvement.

Figures 63 through 66 provide estimates of what the MPG of the car and truck fleet would have been each model year if:

(1) the weight mix had been kept the same as in each of the two base years,

(2) the distribution of acceleration time was kept the same as in each of the two base-line years, and

(3) both the weight distribution and average acceleration time were the same as in the base years.

A similar comparison on the basis of vehicle size and type is presented in Figures 67 through 70.

Table 21

Effect of Performance, Size, and Weight Distributions on Laboratory 55/45 Fuel Economy

	Laboratory 55/45 Fuel Economy			Percent Change From 2004 Fuel Economy		
Distribution Used	Cars	Trucks	Both	Cars	Trucks	Both
Using 1981 Sales Distributions						
Performance	30.1	21.6	25.3	4.9%	3.3%	3.7%
Size	27.9	20.6	23.8	-2.8%	-1.4%	-2.5%
Size and Performance	36.5	22.9	28.4	27.2%	9.6%	16.4%
Weight	33.4	24.9	28.7	16.4%	19.1%	17.6%
Weight and Performance	37.1	27.2	31.6	29.3%	30.1%	29.5%
Ref: 1981 Actuals	25.1	20.1				
Using 1987 Sales Distributions						
Performance	31.3	21.9	25.9	9.1%	4.8%	6.1%
Size	28.7	22.3	25.2	0.0%	6.7%	3.3%
Size and Performance	33.8	23.1	27.6	17.8%	10.5%	13.1%
Weight	33.2	25.4	28.9	15.7%	21.5%	18.4%
Weight and Performance	34.5	26.2	29.9	20.2%	25.4%	22.5%
Ref: 1987 Actuals	28.1	21.6				
Actual 2004 Distribution	28.7	20.9	24.4+			

Effect of Weight and Acceleration on Car Fuel Economy

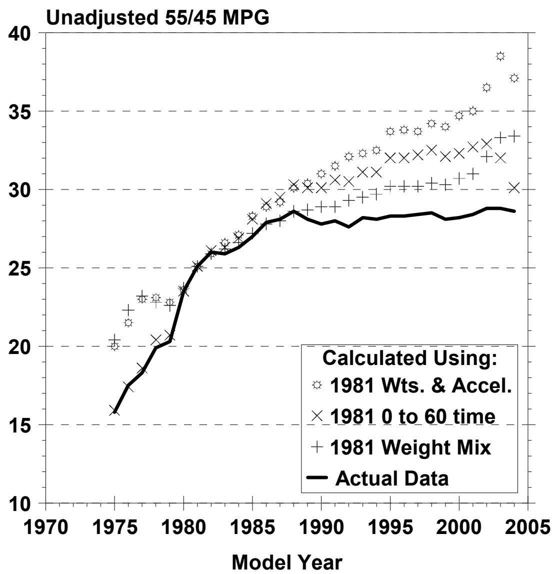

Figure 63

Effect of Weight and Acceleration on Truck Fuel Economy

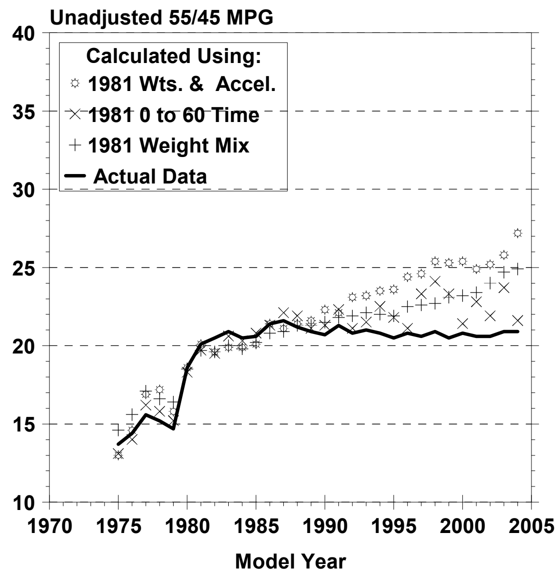

Figure 64

Effect of Weight and Acceleration on Car Fuel Economy

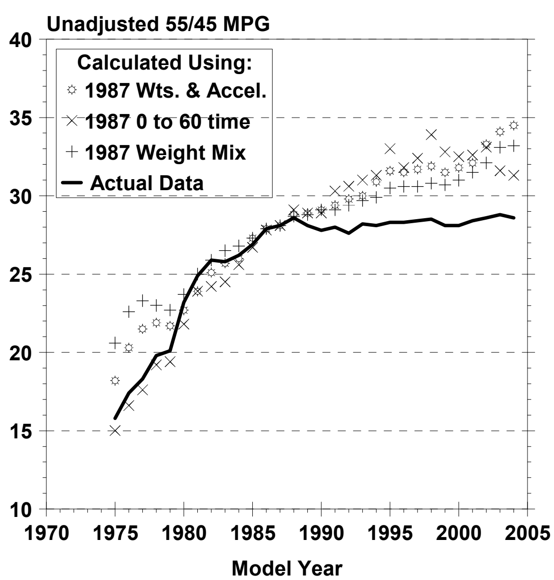

Figure 65

Effect of Weight and Acceleration on Truck Fuel Economy

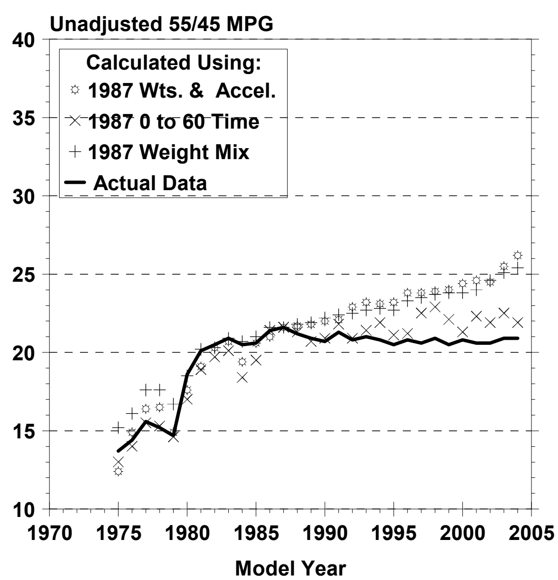

Figure 66

Effect of Vehicle Size, Type & Acceleration on Car Fuel Economy

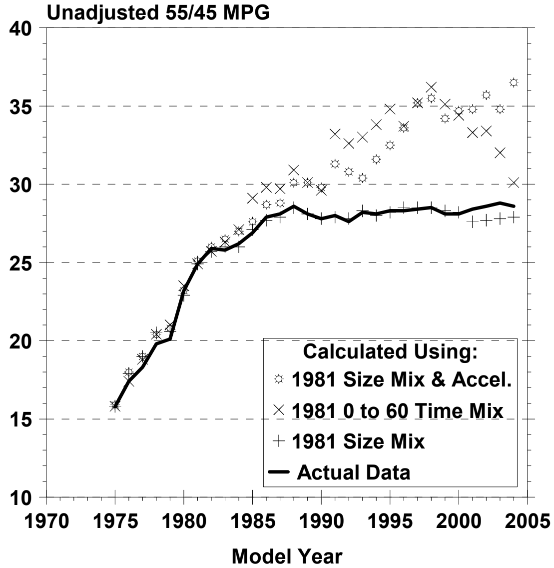

Figure 67

Effect of Vehicle Size, Type & Acceleration on Truck Fuel Economy

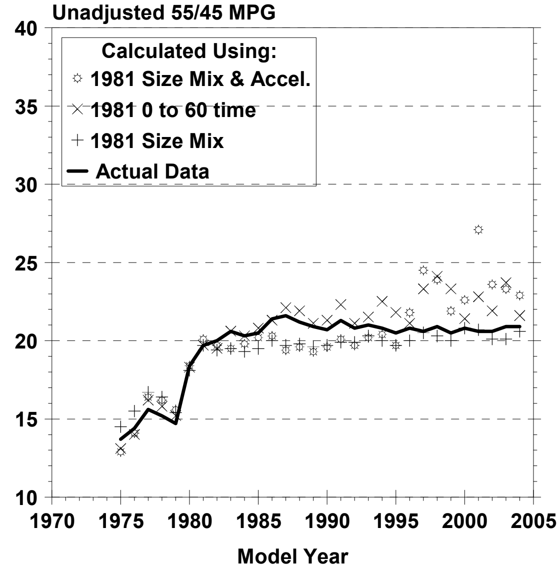

Figure 68

Effect of Vehicle Size, Type & Acceleration on Car Fuel Economy

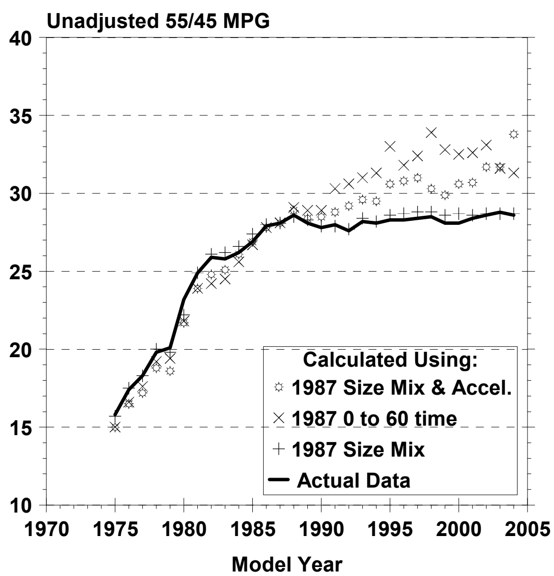

Figure 69

Effect of Vehicle Size, Type & Acceleration on Truck Fuel Economy

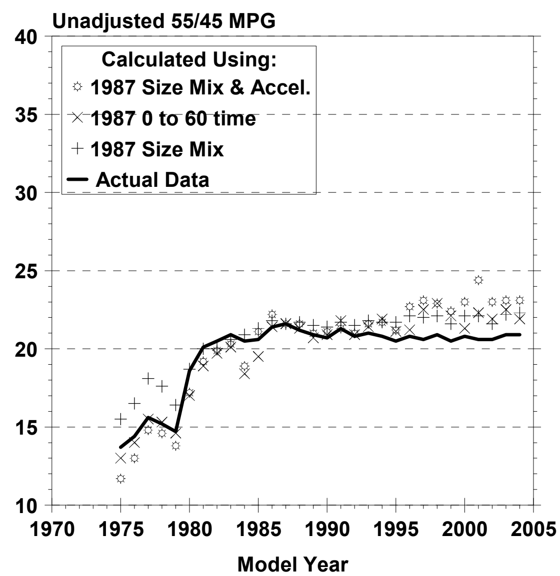

Figure 70

A summary of the different approaches is presented in Table 22. Considering the seven different ways in which fuel economy improvements for the fleet can be estimated, based on the characteristics of the existing fleet, the range of improvements for the fleet is from 9 to 30 percent. The average is 18 percent. Different methods and different base years could, of course, yield different results, and as discussed earlier, the hypothetical fleets that have higher fuel economy tend to be different from today's fleet because while they have higher fuel economy, they also are slower and lighter.

Table 22

Summary of Fuel Economy Improvement Potential

	Laboratory 55/45 Fuel Economy		
Scenario	Cars	Trucks	Both
1 Model Year 2004 Actual Average	28.7	20.9	24.4
2 1981 Weight Mix and 0-to-60 Time	37.1	27.2	31.8
3 1987 Weight Mix and 0-to-60 Time	34.5	26.2	30.2
4 1981 Size Mix and 0-to-60 Time	36.5	22.9	28.6
5 1987 Size Mix and 0-to-60 Time	33.8	23.1	27.9
6 Best 4 Nameplates in Size Class	32.9	23.4	27.4
7 Best 12 Vehicles in Size Class	32.8	24.6	28.2
8 Best 12 Vehicles in Weight Class	32.0	22.8	26.7
Percent Improvement over Model Year 2004 Actual Averages			
2 1981 Weight Mix and 0-to-60 Time	29.3%	30.1%	30.3%
3 1987 Weight Mix and 0-to-60 Time	20.2%	25.4%	23.8%
4 1981 Size Mix and 0-to-60 Time	27.2%	9.6%	17.3%
5 1987 Size Mix and 0-to-60 Time	17.8%	10.5%	14.2%
6 Best 4 Nameplates in Size Class	14.6%	12.0%	11.9%
7 Best 12 Vehicles in Size Class	14.3%	17.7%	15.6%
8 Best 12 Vehicles in Weight Class	11.5%	9.1%	9.4%
Average (all seven scenarios)	19.2%	18.8%	18.3%

Note: Scenario 1 includes hybrids/diesels; all others do not.

VII. Conclusions

1. The trends in light-duty vehicle fuel economy have exhibited four stages over the past 30 years:

    A. a rapid increase from 1975 continuing into the mid-1980s,

    B. a slow increase extending into the late 1980s,

    C. a gradual decline from then until the late 1990s, and

    D. a period of relatively constant fuel economy since then.

2. Model year 2004 light-duty vehicles are estimated to average 20.8 miles per gallon (MPG), about the same value achieved in model year 2003, but six percent below the 1987-88 peak of 22.1 MPG and nearly 60 percent more than the average achieved in 1975.

3. Light truck market share has generally been increasing since 1981. For model year 2004, light trucks are projected to account for 48 percent of all light-duty vehicles. Most of this growth in the light truck market has been led by the increase in the popularity of sport utility vehicles(SUVs), which now account for more than one fourth of all new light-duty vehicles.

4. Compared to 1987 as a benchmark year, this year's fleet is 26 percent heavier, 24 percent faster, and 76 percent more powerful.

5. Technologies important for improving fuel economy including hybrids, CVTs, and diesel engines are represented in the current fleet, but total sales for vehicles equipped with these technologies are not yet significant, i.e., none of them exceed two percent of the light-duty vehicle fleet.

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2004

Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004

Appendixes

Advanced Technology Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

List of Appendixes

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Appendix A

Database Details and Calculation Methods

Light-duty automotive technology and fuel economy trends are examined herein, as in preceding reports in this series [1-30], using the latest and most complete EPA data available. When comparing data in this report with those in previous reports in this series, please note that revisions are made in the data in some model years for which more complete and accurate sales and fuel economy data have become available.

Through model year 2002, the fuel economy, vehicle characteristics, and sales data used for this report were obtained from the most complete databases used for CAFE standards and "gas guzzler" compliance purposes. For all practical purposes, these databases are stable and are not expected to change in the future.

Where available, the model year 2003 data in this report is based on CAFE compliance data submitted to EPA by March 31, 2004. For those MY2003 cases for which compliance data was yet not available, EPA used data that included confidential sales projections submitted to the agency by the automotive manufacturers, but updated the sales data to take into account information reported in trade publications.

For model year 2004, EPA has used exclusively confidential projected sales data that the auto companies are required to submit to the Agency for the Federal Government's fuel economy public information programs: the *Fuel Economy Guide* and the MPG labels that are placed on new vehicles. The source database was frozen in October 2003 for all model years other than 2003.

As shown in table A-1, the final fuel economy averages used in this report are often different from the initial estimates by about one percent.

* Numbers in brackets denote references listed in the references section of this report.

Appendix A

Table A-1 compares average 55/45 laboratory fuel economy for model years 1998 through 2002 at three points in time:

(1) an initial estimate determined early in each model year using just projected sales,

(2) a revised estimate determined by using trade publication sales data that were obtained after the end of each model year, but before the data used for the CAFÉ calculations were submitted to the Federal Government, and

(3) final fuel economy values determined from compliance data provided by the manufacturers to the Federal Government after the end of the model year.

The next report in this series will provide updated data for model years 2003 and 2004 based on information available at that time.

Table A-1

Comparison of Laboratory 55/45 MPG

	Model Year	Initial Estimate	Revised Estimate	Final Value
Cars	1998	28.6	28.6	28.5
	1999	28.1	28.2	28.1
	2000	28.1	28.3	28.2
	2001	28.3	28.3	28.4
	2002	28.5	28.5	28.6
Trucks	1998	20.6	20.6	20.9
	1999	20.3	20.4	20.5
	2000	20.5	20.5	20.8
	2001	20.3	20.4	20.6
	2002	20.4	20.3	20.6
Both	1998	24.4	24.4	24.5
	1999	23.8	24.0	24.1
	2000	24.0	23.9	24.3
	2001	23.9	24.0	24.2
	2002	24.0	23.9	24.1

The fuel economy data used in some previous editions in this series of reports were laboratory data, with no correction for laboratory to on-road shortfall, alternative fuels capability "credits", or test procedure adjustment. Accordingly, the MPG values in previous reports in this series were always slightly lower than those reported by the Department of Transportation (DOT) and significantly higher than those provided in the *Fuel Economy Guide*. All fuel economy averages in this report are sales-weighted harmonic averages.

Appendix A

Averaging Fuel Economy Values

Dimensionally, fuel economy is miles divided by gallons. Then, presented with more than one fuel economy value, an approach to averaging the values is to compute the result by determining the total miles traveled and dividing that by the total gallons used.

Example: A motorist's fuel economy log for May shows that 704 miles were accumulated around town in which the fuel economy was 16 MPG, and one 216 mile trip was taken on which the fuel economy was 24 MPG. What is the average fuel economy for May?

The total miles are 704 + 216 = 920. The total gallons thus, are 704 / 16 = 44 plus 216 / 24 = 9; 53 gallons. The average MPG is 920 / 53 = 17.4 MPG. Notice that the arithmetic average of the two fuel economy values (16 + 24) / 2 = 20 MPG gives an individual result which is higher than the total miles/total gallons result.

Even if the around-town miles traveled and the trip-miles traveled were the same (460 miles), the average fuel economy would not be 20; it would be 19.2 MPG. This is because in the total miles/total gallons approach, *fuel consumption* is arithmetically averaged, but *fuel economy* is harmonically averaged, so for the second example (equal trip distances), the calculation would be:

$$\text{average MPG} = 2 / (1/16 + 1/24) = 19.2 \text{ MPG},$$

which is the same as arithmetically averaging the two fuel consumption values.

A specific example of this type of averaging approach is shown in the calculation of the overall average fuel economy using the EPA "city" (MPG_C) and EPA "highway" (MPG_H) fuel economy values.

$$\begin{aligned}\text{Average MPG} &= \frac{\text{Total Miles}}{\text{Total Gallons}}\\ &= \frac{\text{Total Miles}}{\text{City Gallons + Highway Gallons}}\\ &= \frac{\text{Total Miles}}{\text{City Miles/City MPG + Highway Miles/Highway MPG}}\end{aligned}$$

Now, if city miles are 55 percent of total miles and highway miles are the remaining 45 percent, after dividing by total miles,

$$\text{Average MPG} = \frac{1}{(.55/MPG_C) + (.45/MPG_H)}$$

and this average MPG is called the EPA 55/45 MPG value.

The same approach can be used when the average MPG of a group of vehicles with different MPG values is to be calculated. Suppose a fleet of 100,000 vehicles is made up of two classes, one of 70,000 vehicles whose fuel economy is 10 MPG and the other of 30,000 vehicles whose fuel economy is 14 MPG. Each vehicle in the fleet is assumed to travel the same number of miles (**M**),

$$\text{Total Miles} = 100{,}000\ \mathbf{M}$$

$$\text{Total Gallons} = 70{,}000\ \mathbf{M} / 10 + 30{,}000\ \mathbf{M} / 14$$

and the average fuel economy is:

$$\text{Average Fuel Economy} = \frac{1}{.7/10 + .3/14}$$

$$= 10.9 \text{ MPG}$$

where .7 and .3 are the relative shares of each vehicle class in the fleet. Notice that, again, the arithmetic average of the class fuel economy values (10 + 14)/2 = 12 MPG is higher.

In general, some form of a weighted harmonic mean is used when averaging different fuel economy values.

Appendix A

Use of Adjusted MPG

In prior reports in this series, up to and including the one for MY2000, the fuel economy values used were just the laboratory-based city, highway, and combined MPG values — the same ones that are used as the basis for compliance with the fuel economy standards and the gas guzzler tax. Since the laboratory MPG values tend to over predict the MPG achieved in actual use, adjusted MPG values are used for the Government's fuel economy information programs: the *Fuel Economy Guide* and the *Fuel Economy Labels* that are on new vehicles.

The adjusted city MPG is obtained by multiplying the laboratory city MPG by 0.90, and the adjusted highway MPG is obtained by multiplying the laboratory highway MPG value by 0.78. If a combined "55/45" MPG value is calculated, the resulting MPG value is about 15 percent lower than the comparable value using the laboratory-based MPG values. It should be noted that an adjusted composite MPG value is *not* used in the Government's fuel economy information programs discussed above.

Starting with the report issued for MY2001, this series of reports has provided trends in adjusted MPG values in addition to the laboratory MPG values. In this way, the MPG trends can be seen for those who are interested in laboratory MPG and for those interested in MPG values which can be considered to be an estimate of on-road fuel economy. In the tables, these two MPG values are called "Laboratory MPG," "Adjusted MPG" and abbreviated "ADJ" MPG and "LAB" MPG.

Where only one MPG value is presented in this report, it is the "adjusted composite 55/45 combined MPG", i.e.,

$$MPG_{55/45} = 1 / (.55/MPG_C + .45/MPG_H)$$

where MPG_C is 0.9 times the laboratory fuel economy on the EPA city driving cycle, and MPG_H is 0.78 times the laboratory fuel economy on the EPA highway driving cycle. Appendix D provides additional data on city and highway driving.

To facilitate comparison with data in previous reports in this series, most data tables include what the $MPG_{55/45}$ value would have been, had the laboratory fuel economy values not been adjusted downward, as well as the adjusted city, highway, and combined 55/45 fuel economy values. Table A-2 compares CAFE data reported by The Department of Transportation (DOT) with EPA adjusted and laboratory fuel economy data. The DOT values are higher than the values used in the report by a few tenths of an MPG due to test procedure adjustment factors and alternative fuel credits.

Appendix A

Table A-2

EPA Adjusted, Laboratory, and NHTSA CAFE Fuel Economy Values by Model Year

	Cars				Trucks				Both Cars and Trucks			
Model Year	EPA Adj.	EPA Unadj.	NHTSA (CAFE)	Diff.	EPA Adj.	EPA Unadj.	NHTSA (CAFE)	Diff.	EPA Adj.	EPA Unadj.	NHTSA (CAFÉ)	Diff.
1975	13.5	15.8	n/a		11.6	13.7	n/a		13.1	15.3	n/a	
1976	14.9	17.5	n/a		12.2	14.4	n/a		14.2	16.7	n/a	
1977	15.6	18.3	n/a		13.3	15.6	n/a		15.1	17.7	n/a	
1978	16.9	19.9	19.9	0.0	12.9	15.2	n/a		15.8	18.6	n/a	
1979	17.2	20.3	20.3	0.0	12.5	14.7	18.2		15.9	18.7	20.1	
1980	20.0	23.5	24.3	0.8	15.8	18.6	18.5	-0.1	19.2	22.5	23.1	0.6
1981	21.4	25.1	25.9	0.8	17.1	20.1	20.1	0.0	20.5	24.1	24.6	0.5
1982	22.2	26.0	26.6	0.6	17.4	20.5	20.5	0.0	21.1	24.7	25.1	0.4
1983	22.1	25.9	26.4	0.5	17.8	20.9	20.7	-0.2	21.0	24.6	24.8	0.2
1984	22.4	26.3	26.9	0.6	17.4	20.5	20.6	0.1	21.0	24.6	25.0	0.4
1985	23.0	27.0	27.6	0.6	17.5	20.6	20.7	0.1	21.3	25.0	25.4	0.4
1986	23.8	27.9	28.2	0.3	18.3	21.4	21.5	0.1	21.9	25.7	25.9	0.2
1987	24.0	28.1	28.5	0.4	18.4	21.6	21.7	0.1	22.1	25.9	26.2	0.3
1988	24.4	28.6	28.8	0.2	18.1	21.2	21.3	0.1	22.1	25.9	26.0	0.1
1989	24.0	28.1	28.4	0.3	17.8	20.9	21.0	0.1	21.7	25.4	25.6	0.2
1990	23.7	27.8	28.0	0.2	17.7	20.7	20.8	0.1	21.5	25.2	25.4	0.2
1991	23.9	28.0	28.4	0.4	18.1	21.3	21.3	0.0	21.7	25.4	25.6	0.2
1992	23.6	27.6	27.9	0.3	17.8	20.8	20.8	0.0	21.3	24.9	25.1	0.2
1993	24.1	28.2	28.4	0.2	17.9	21.0	21.0	0.0	21.4	25.1	25.2	0.1
1994	24.0	28.1	28.3	0.2	17.7	20.8	20.8	0.0	21.0	24.6	24.7	0.1
1995	24.2	28.3	28.6	0.3	17.5	20.5	20.5	0.0	21.1	24.7	24.9	0.2
1996	24.2	28.3	28.5	0.2	17.8	20.8	20.8	0.0	21.2	24.8	24.9	0.1
1997	24.3	28.4	28.7	0.3	17.6	20.6	20.6	0.0	20.9	24.5	24.6	0.1
1998	24.4	28.5	28.8	0.3	17.8	20.9	21.1	0.2	20.9	24.5	24.7	0.2
1999	24.1	28.2	28.3	0.2	17.5	20.5	20.9	0.4	20.6	24.1	24.5	0.4
2000	24.1	28.2	28.5	0.3	17.7	20.8	21.3	0.3	20.7	24.3	24.8	0.5
2001	24.3	28.4	28.8	0.4	17.6	20.6	20.9	0.3	20.7	24.2	24.4	0.5
2002	24.5	28.6	28.9	0.3	17.6	20.6	21.3	0.7	20.6	24.1	24.6	0.5
2003	24.7	28.9			17.8	20.9			20.7	24.2		
2004	24.6	28.7			17.9	20.9			20.8	24.4		

Notes:

“Diff.” is difference between NHTSA value and EPA laboratory value.

NHTSA data for MY1979 Trucks is just for vehicles with less than 6000 pound GVW.

EPA data is final through MY2002, preliminary for MY2003, MY2004.

Appendix A

Use of 3-Year Moving Averages

Use of the three-year moving averages, which effectively smooth the trends, results in an improvement in discerning real trends from what might be relatively small year-to-year variations in the data. For this report, these three-year moving averages are tabulated at their midpoint. For example, the midpoint for model years 2002, 2003, and 2004 is model year 2003. The data used to generate the trend lines in Figure 1 are provided in Table A-3.

Table A-3

Light-Duty Vehicle Laboratory Fuel Economy and Truck Sales Fraction

	Actual Data				Three Year Moving Average			
	55/45 Fuel Economy			Truck	55/45 Fuel Economy			Truck
Year	Cars	Trucks	Both	Sales Fraction	Cars	Trucks	Both	Sales Fraction
1975	15.8	13.7	15.3	0.194	****	****	****	*****
1976	17.5	14.4	16.7	0.212	17.1	14.5	16.5	0.202
1977	18.3	15.6	17.7	0.200	18.5	15.0	17.6	0.213
1978	19.9	15.2	18.6	0.227	19.5	15.2	18.3	0.216
1979	20.3	14.7	18.7	0.222	21.1	16.0	19.8	0.205
1980	23.5	18.6	22.5	0.165	22.8	17.5	21.5	0.187
1981	25.1	20.1	24.1	0.173	24.8	19.7	23.7	0.178
1982	26.0	20.5	24.7	0.197	25.7	20.5	24.5	0.198
1983	25.9	20.9	24.6	0.223	26.1	20.6	24.6	0.220
1984	26.3	20.5	24.6	0.239	26.4	20.7	24.7	0.239
1985	27.0	20.6	25.0	0.254	27.1	20.8	25.1	0.259
1986	27.9	21.4	25.7	0.283	27.7	21.2	25.5	0.272
1987	28.1	21.6	25.9	0.278	28.2	21.4	25.8	0.286
1988	28.6	21.2	25.9	0.298	28.3	21.2	25.7	0.294
1989	28.1	20.9	25.4	0.307	28.2	20.9	25.5	0.302
1990	27.8	20.7	25.2	0.302	28.0	21.0	25.3	0.310
1991	28.0	21.3	25.4	0.322	27.8	20.9	25.2	0.319
1992	27.6	20.8	24.9	0.334	27.9	21.0	25.1	0.339
1993	28.2	21.0	25.1	0.360	28.0	20.9	24.9	0.364
1994	28.1	20.8	24.6	0.398	28.2	20.8	24.8	0.379
1995	28.3	20.5	24.7	0.380	28.2	20.7	24.7	0.393
1996	28.3	20.8	24.8	0.400	28.3	20.6	24.7	0.401
1997	28.4	20.6	24.5	0.423	28.4	20.8	24.6	0.424
1998	28.5	20.9	24.5	0.449	28.4	20.7	24.4	0.441
1999	28.2	20.5	24.1	0.450	28.3	20.7	24.3	0.449
2000	28.2	20.8	24.3	0.449	28.3	20.6	24.2	0.453
2001	28.4	20.6	24.2	0.461	28.4	20.6	24.2	0.465
2002	28.6	20.6	24.1	0.485	28.6	20.7	24.2	0.484
2003	28.9	20.9	24.2	0.507	28.7	20.8	24.2	0.491
2004	28.7	20.9	24.4	0.483	****	****	****	*****

Appendix A

Other Variables

All vehicle weight data are based on inertia weight class (nominally curb weight plus 300 pounds). For vehicles with inertia weights up to and including the 3000-pound inertia weight class, these classes have 250-pound increments. For vehicles above the 3000-pound inertia weight class (i.e., vehicles 3500 pounds and above), 500-pound increments are used.

All interior volume data for cars built after model year 1977 are based on the metric used to classify cars for the DOE/EPA *Fuel Economy Guide*. The car interior volume data in this report combine that of the passenger compartment and trunk/cargo space. In the *Fuel Economy Guide*, interior volume is undefined for the two-seater class; for this series of reports, all two-seater cars have been assigned an interior volume value of 50 cubic feet.

The light truck data used in this series of reports includes only vehicles classified as light trucks with gross vehicle weight ratings (GVWR) up to 8,500 pounds. Vehicles with GVWR above 8,500 are not included in the database used for this report. Omitting these vehicles influences the overall averages for all variables studied in this report. The most recent estimates we have made for the impact of these greater than 8500-lb GVWR vehicles was made for model year 2001. In that year, the roughly 931,000 vehicles above 8500 lb GVWR were about six percent of all vehicles less than 8500 lb GVWR. A substantial fraction (42 percent) of the vehicles above 8500 lb GVWR were powered by diesel engines, and three-fourths of the vehicles over 8500 lb GVWR were pickup trucks. Adding in the trucks above 8500 GVW lb increased the truck market share by three percentage points.

Based on a limited amount of actual laboratory fuel economy data, trucks with GVWR greater than 8500 lb GVWR are estimated to have fuel economy values about 14 percent lower than the average of trucks below 8500 lb GVWR. The combined fleet of all vehicles under 8500 lb GVWR and trucks over 8500 lb GVWR is estimated to average about nine percent less in fuel economy compared to that for just the vehicles with less than 8500 lb GVWR.

In addition to fuel economy, some tables in this report contain alternate measures of vehicle fuel efficiency as used in reference 17. “Ton-MPG” is defined as a vehicle’s MPG multiplied by its inertia weight in tons. This metric provides an indication of a vehicle’s ability to move weight (i.e., its own plus a nominal payload). Ton-MPG is a measure of powertrain/drive-line efficiency. Just as an increase in vehicle MPG at constant weight can be considered an improvement in a vehicle’s efficiency, an increase in a vehicle’s weight-carrying capacity at constant MPG can also be considered an improvement.

Appendix A

"Cubic-feet-MPG" for cars is defined in this report as the product of a car's MPG and its interior volume, including trunk space. This metric associates a relative measure of a vehicle's ability to transport both passengers and their cargo. An increase in vehicle volume at constant MPG could be considered an improvement just as an increase in MPG at constant volume can be.

"Cubic-feet-ton-MPG" is defined in this report as a combination of the two previous metrics, i.e., a car's MPG multiplied by its weight in tons and also by its interior volume. It ascribes vehicle utility to the ability to move both weight and volume.

This report also includes an estimate of 0-to-60 mph acceleration time, calculated from engine rated horsepower and vehicle inertia weight, from the relationship:

$$t = F\ (HP/WT)^{-f}$$

where the values used for F and f coefficients are .892 and .805 respectively for vehicles with automatic transmissions and .967 and .775 respectively for those with manual transmissions [31]. Other authors [32, 33, and 34] have evaluated the relationships between weight, horsepower, and 0-to-60 acceleration time and have calculated and published slightly different values for the F and f coefficients. Since the equation form and coefficients were developed for vehicles with conventional powertrains with gasoline-fueled engines, we have not used the equation to estimate 0-to-60 time for vehicles with hybrid powertrains or diesel engines. Published values are used for these vehicles instead.

The 0-to-60 estimate used in this report is intended to provide a quantitative time "index" of vehicle performance capability. It is the authors' engineering judgment that, given the differences in test methods for measuring 0-to-60 time and given the fact that the weight is based on inertia weight, use of these other published values for the F and f coefficients would not result in a significantly different 0-to-60 relative performance estimate. The results of a similar calculation of estimated "top speed" are also included in some tables.

Appendix A

Marketing Groups

In its century of evolution, the automotive industry existed first as small, individual companies that relatively quickly grew into larger corporations. In that context, the historic term 'manufacturer' usually meant a corporation that was associated with a single country that manufactured vehicles for sale in just that country and perhaps exported vehicles to a few other countries, too. Since the first report in this series was prepared, the nature of the automotive industry has changed substantially, and it has evolved into one in which global consolidations and alliances among heretofore independent manufacturers have become the norm, rather than the exception.

The reports in this series include analysis of fuel economy trends in terms of the whole fleet of cars and light trucks and in various subcategories of interest, e.g., by weight class, by size class, etc. In addition, there has been a treatment of trends by groups of manufacturers. Initially, these groups were derived from the "Domestic" and "Import" categories which are part of the automobile fuel economy standards categories. This classification approach evolved into a market segment approach in which cars were apportioned to a "Domestic," "European," and "Asian" category, with trucks classified as "Domestic" or "Imported." As the automotive industry has become more transnational in nature, this type of vehicle classification has become less useful.

In this report, trends by groups of manufacturers are now used instead of the Domestic/Imported type grouping to reflect the transnational and transregional nature of the automobile industry. To reflect the transition to an industry in which there are only a small number of independent companies, the fleet has been divided into eight segments consisting of three multiple partner "marketing groups," four groups with just a few partners, and an eighth catch-all group ("Others") that contains those manufacturers that have not been assigned to one of the seven major marketing groups.

Taken together, the seven major marketing groups comprise over 97 percent of the MY2004 new vehicle market in the U.S. Note that, because the sales data provided to EPA by these manufacturers is confidential and cannot be released to the public, trends in market share by marketing group cannot be included in this report.

Appendix A

The seven major marketing groups used in this report are:

1. The General Motors Group includes GM and those companies which GM owns or has a substantial affiliation with, i.e., Opel, Saab, Isuzu, Fiat, Subaru, Suzuki, and Daewoo;

2. The Ford Motor Group includes Ford, Jaguar, Volvo, Land Rover, Aston Martin, and Mazda;

3. The DaimlerChrysler Group includes Chrysler, Mercedes Benz, Mitsubishi, Hyundai, and Kia;

4) The Toyota Group includes Toyota, Scion and Lexus;

5) The Honda Group includes Honda and Acura;

6) The Nissan Group include Nissan and Infiniti; and

7) The VW Group includes Volkswagen, Audi, SEAT, Skoda, and Bentley.

It is expected that these marketing groups will continue to expand as other consolidations in the automotive industry occur; for example, Daewoo was added to the GM group for model year 2003.

Appendix A

Vehicle Classification

Grouping all vehicles into classes and then constructing time trends of parameters of interest, like MPG, can provide interesting and useful results. These results, however, are a strong function of the class definitions. Classes based on other definitions than those used in this report are possible, and results from these other classifications may also be useful

For cars, vehicle classification as to vehicle type, size class, and manufacturer/origin generally follows fuel economy label, *Fuel Economy Guide*, and fuel economy standards protocols; exceptions are listed in Table A-4. In many of the passenger car tables, large sedans and wagons are aggregated as "Large," midsize sedans and wagons are aggregated as "Midsize," and "Small" includes all other cars. In some of the car tables, an alternative classification system is used, namely: Large Cars, Large Wagons, Midsize Cars, Midsize Wagons, Small Cars, and Small Wagons with the EPA Two-Seater, Mini-Compact, Subcompact, and Compact car classes combined into the "Small Car" class.

The truck classification scheme used for all model years in this report is slightly different from that used prior to 1999 in this series, because pickups, vans, and sports utility vehicles (SUVs) are sometimes each subdivided as "Small," "Midsize," and "Large." These truck size classifications are based primarily on published wheelbase data according to the following criteria:

	Pickup	Van	SUV
Small	Less than 105"	Less than 109"	Less than 100"
Midsize	105" to 115"	109" to 124"	100" to 110"
Large	More than 115"	More than 124"	More than 110"

This classification scheme is similar to that used in many trade and consumer publications. For those vehicle nameplates with a variety of wheelbases, the size classification was determined by considering only the smallest wheelbase produced.

The classification of a vehicle for this report is based on the authors' engineering judgment and is not a replacement for definitions used in implementing automotive standards legislation.

Appendix A

Table A-4 **Vehicle Classification Exceptions**

Group/Manufacturer/Vehicles		Years	Are Classified As:
DC:	Chrysler Colt 4WD Wagon	All	Small Wagon
DC:	Chrysler Colt Vista	All	Small Van
DC:	Chrysler PT Cruiser	All	Small Wagon
DC:	Chrysler Summit Wagon	All	Small Van
DC:	Dodge Ramcharger	All	Car
DC:	Eagle 4WD Wagon	All	Car
DC:	Mitsubishi Expo	All	Small Van
DC:	Mitsubishi Space Wagon	All	Small Van
DC:	Chrysler Pacifica	All	Large Wagon
Ford:	Ford Pinto Van	All	Car
Ford:	Volvo V70 XC	All	Midsize Wagon
GM:	Isuzu Oasis	All	Midsize Van
GM:	Pontiac Vibe	All	Small Wagon
GM:	Subaru 4WD Sedans/Wagons	All	Cars
GM:	Subaru Forester	All	Small Utility
GM:	Subaru Baja	All	Small Pickup
GM:	Suzuki X-90	All	Small Utility
Toyota:	Lexus RX300	All	Midsize Utility
Toyota:	Matrix	All	Small Wagon
Honda:	Honda Odyssey	All	Midsize Van
VW:	Audi Allroad	All	Midsize Wagon

Appendix A

Other Appendixes

Appendix B lists the model year 2004 nameplates by size class and their sales-weighted MPG averages as of the data freeze date.

Appendix C contains information about how the factors used in the 55/45 MPG calculation relate to the fraction of driving that is "urban" and also contains data on how the urban or "city fraction" of travel has changed over time.

Appendix D lists and describes the most, and least, fuel efficient vehicles for model years 1975 to 2004. This appendix also includes the sales weighted fuel economy distribution data.

Appendixes E through H contain a series of tables in which the fleet is grouped into classes and stratified based on vehicle type, vehicle type and size, EPA car class, and inertia weight class, respectively.

Appendixes I through L contain a series of tables in which the fleet is grouped into classes and stratified based on drive, transmission type and number of gears, cylinder count, and by the number of engine valves per cylinder, respectively.

Appendix M contains a series of tables in which the fleet is stratified by marketing group.

Appendix N contains tables that provide detailed data related to the section of this report that discusses the characteristics of fleets comprised of fuel efficient vehicles.